

ELEMENTS
OF THE
THEORY AND PRACTICE
OF
CHYMISTRY.

TRANSLATED from the FRENCH of
M. MACQUER.

Member of the Royal Academy of Sciences, and
Professor of Medicine in the University of Paris.

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E L E M E N T S

O F T H E

P R A C T I C E o f C H Y M I S T R Y .



C H A P. V.

O F O P E R A T I O N S O N E S S E N T I A L O I L S .

P R O C E S S I .

The Rectification of Essential Oils.

PUT into a cucurbit the essential oil you propose to rectify. Set the cucurbit in a *balneum mariae* ; fit to it a head of tin, or of copper tinned, together with its refrigeratory ; and lute on a receiver. Make the water in the bath boil, and keep up this degree of heat till nothing more will come over. When the distillation is finished, you will find in the receiver a rectified essential oil, which will be clearer, thinner, and better scented, than before it was thus re-distilled ; and in the bottom of the cucurbit will be left a matter of a deeper colour, more tenacious, more resinous, and of a less grateful smell.

OBSERVATIONS.

Essential oils, even the purest, the best prepared, and the thinnest, suffer great changes, and are much impaired by growing old, they gradually turn thick and resinous; their sweet, grateful scent is lost, and succeeded by a more disagreeable smell, somewhat like that of turpentine. The cause of these changes is that their finest and most volatile part, that which contains most of the odorous principle, is dissipated and separated from that which contains least of it; which therefore grows thicker, and comes so much the nearer to the nature of a resin, as the quantity of acid, that was distributed through the whole oil before the dissipation of the more volatile part, is, after such dissipation, united and concentrated in the heaviest part; the acid in oils being much less volatile than the odorous part, to which alone they owe their levity.

Hence it appears what precautions are to be used, for preserving essential oils, as long as possible, without spoiling. They must be kept in a bottle perfectly well stopped, and always in a cool place, because heat quickly dissipates the volatile parts. Some authors direct the bottle to be kept under water.

If these oils should grow thick and resinous by age, yet they are not to be thrown away. We shall shew in the analysis of balsams and resins, that from these thick and even solid substances, essential oils may be drawn, as thin and as limpid as from plants. Essential oils thickened by time may, therefore, be treated like balsams, and actually analyzed, by separating all the subtile odorous matter they contain from their thick acid parts. For this purpose they need only be distilled with a degree of heat just sufficient to elevate the thin odorous parts without raising the thick matter.

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The residue left at the bottom of the vessel, because it could not rise in distillation, is much thicker and less odorous than the oil was before rectification. The reason of this is evident, and follows from what hath just been said. This remainder dissolves in spirit of wine more readily, and in greater quantity, than the light oil drawn from it; because it contains more acid, and because oils owe their solubility in this menstruum to their acid part as is proved in our memoir on oils already quoted.

When we come to treat of resins, we shall enquire more particularly what this remainder is, and what principles it yields when analyzed: in this place it is sufficient to take notice that though all the oil, of which it made a part, came over at first with the heat of boiling water, yet it cannot now be raised by the same degree of heat in distillation; because it is not now combined with the principle of odour which gives the oil its volatility, and because it is rendered sluggish by being clogged with too great a proportion of acid.

From what hath been already said it must be concluded, that essential oils suffer great diminution by being rectified; and that in proportion to the quantity of resinous matter left behind. All this resinous matter, while combined with a proper quantity of the odorous principle of the plant, (that is, at the time of its being distilled, and a little while after) was really an essential oil: the change of its nature therefore is entirely owing to its having lost that principle.

An essential oil, though rectified, is still as apt to change and be spoiled as before, because it still continues to lose its odorous principle by degrees. After some time, therefore, it requires a second rectification, which again lessens its quantity. In short, it is plain that oils will, in a number of years, greater or smaller according to their nature, and the

the manner in which they are kept, be wholly changed, and metamorphosed into a resinous matter, from which no thin oil can be drawn with the heat of boiling water: and this is a proof of the fugacity of that odorous principle, or *spiritus rector* of plants, which, when united with their lightest oil, gives it the character of an essential oil.

This resinous matter, to which essential oils are finally reduced, being subjected to repeated distillations, with a degree of heat superiour to that of boiling water, is still capable of yielding a certain portion of a thin, limpid, sweet-scented oil, which is as light as an essential oil; as we observed before is the case with fat oils drawn by expression: but the thin oil obtained by this means, though it possesses almost all the properties of an essential oil, is not for all that a genuine one; seeing it hath not the same odour with the plant from which it was originally drawn.

Essential oils must be rectified in the *balneum mariae*, as ordered in the process: for, as some of the oil touches the sides of the vessel in the operation, if that vessel be made hotter than boiling water, the thick matter will rise with the thin oil, which therefore will not be rectified.

Rectification is of use not only for procuring to essential oils the tenuity and levity they may have lost by age, but also to separate them from other oily matters with which they may be adulterated. If, for instance, an essential oil be not properly distilled; if, by the addition of too much salt, the water have acquired a degree of heat greater than that of pure boiling water, and if, in consequence thereof, some of the heavy oil of the plant have risen with the essential oil, and mixed therewith, the essential oil may, by rectification, be separated from this heterogeneous oil; which, being heavier and incapable of rising with the heat of pure boiling water, will remain at the bottom of the vessel.

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PRACTICE OF CHYMISTRY.

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The effect will be the same, if your essential oil be falsified with a mixture of any fat oil, as is often the case : for, some of them being extremely dear, the vender frequently adds a portion of fat oil to encrease the quantity. For this purpose oil of ben is generally used.

When an essential oil is thus falsified with a mixture of any fat oil, it may be discovered by letting a few drops of it fall into rectified spirit of wine ; which will dissolve the essential oil only, leaving the fat oil quite untouched.

Essential oils are sometimes falsified by mixing them with a certain quantity of spirit of wine. This fraud doth not render their smell less fragrant : on the contrary, it becomes rather more agreeable and quicker. In order to try an oil suspected of being falsified in this manner, drop a little of it into very clear water. If a milky cloud appear in the water, be assured the oil is mixed with spirit of wine : for as this liquor unites more readily with water than with oil, it quits the oil with which it was mixed to incorporate with the water : meantime a good deal of the oil, that was dissolved by the spirit of wine, and is now separated from it by the intervention of water, necessarily remains dispersed through this water in very small particles ; and these form the milky cloud produced on this occasion.

An essential oil may also be adulterated with another essential oil that is much more common, and of much less value. Those who practise this fraud generally employ oil of turpentine for that purpose, on account of its cheapness and tenuity. The cheat is easily discovered by moistening a linen rag with the oil supposed to be thus falsified, and then holding the rag a little before the fire, which presently dissipates the odorous part of the falsified oil. This odour, which prevented our distinguishing that of the oil of turpentine, being vanished, the peculiar smell

smell of the turpentine, which is much more permanent, remains alone ; and is so perceptible that it cannot easily be mistaken.

Those, who are much accustomed to see and examine essential oils, have seldom occasion to make the experiments here proposed for discovering their qualities. A certain degree of thickness, partaking of unctuousity, in an essential oil, convinces them that it is falsified with a fat oil : on the other hand a greater degree of tenuity, together with a quicker smell, than a pure essential oil ought to have, discovers the admixture of spirit of wine. Lastly, any one, whose sense of smelling is not very dull, will easily discover the odour of the oil of turpentine, though disguised by that of the essential oil with which it is mixed.

P R O C E S S II.

To fire Oils by combining them with highly concentrated Acids : instanced in Oil of Turpentine.

MIX together, in a glass, equal parts of concentrated oil of vitriol, and highly smoking fresh drawn spirit of nitre : pour this mixture at several times, but suddenly, on three parts of oil of turpentine, set for that purpose in a glass basin. By a part here must be understood a dram at least. A most violent commotion, accompanied with smoke, will immediately be raised in the liquors, and the whole will take fire in an instant, flame, and be consumed.

O B S E R V A T I O N S.

There is not in Chymistry a phenomenon more extraordinary, and more surprising, than the firing of oils by mixing them with acids. It could never

have been suspected that a mixture of two cold liquors would produce a sudden, violent, bright, and lasting flame, like that we are at present considering. Beccher gave notice, in his *Physica Subterranea*, that highly rectified spirit of wine would be set on fire by mixing it with highly concentrated oil of vitriol.

Afterwards Borrichius, a Danish Chymist, published a process for kindling oil of turpentine by mixing it with the nitrous acid, as we find in the philosophical transactions of Copenhagen for the year 1671. Most Chymists have since tried to repeat those experiments, and particularly to fire the oil of turpentine by mixing it with oil of vitriol, or spirit of nitre; but to no purpose, when they made use of the oil of vitriol, till Mr. Homberg told us, in the memoirs of the academy of sciences for 1701, that he had fired oil of turpentine by mixing it with oil of vitriol.

To make the experiment succeed he requires
“ that the oil of vitriol be dephlegmated as much
“ as possible, and that the oil of turpentine be
“ the last that comes over in distillation, which is
“ thick like a syrop, and of a dark-brown colour;
“ for that which is white, and rises at the beginning of the distillation, never takes fire.” These are his own words: but no body else hath ever succeeded in making the experiment.

Tournefort had succeeded, a little before Homberg, in firing, not oil of turpentine indeed, in which he always failed, but the oil of saffrafras, by mixing it with an equal quantity of well dephlegmated spirit of nitre. Homberg came afterwards, as appears by the memoirs of the academy for the year 1702, to fire with spirit of nitre the essential oils of the aromatic plants of India; and in 1706 Mr. Rouviere fired, with spirit of nitre, the empyreumatic oil of guaiacum. While this oil of guaiacum is burning, a porous spongy body rises from
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the midst of the flame, to the height of about two feet above the vessel.

Lastly, several years after all these discoveries, Messrs. Geoffroy and Hoffman, the one at Paris, and the other at Hall in Saxony, found a way to fire the æthereal oil of turpentine, each by a different process: yet agreeing in this, that they both combined the vitriolic acid with the nitrous, and with this compound acid fired that ætherial essential oil, which is one of the thinnest, and probably for that very reason, the most unfit to produce a flame with acids.

The most celebrated chymists, as appears from this short account, have employed themselves in firing essential oils; but nobody attempted the experiment on fat oils. It was not so much as suspected that they were capable of taking fire after this manner, till in 1745 I read before the academy a memoir on oils, which I have already mentioned, and in which I express myself thus:

“ I put two ounces and a half of walnut oil in-
“ to the bottom part of a broken retort, having the
“ figure of a cap, or concave hemisphere; and
“ poured thereon two ounces of smoking spirit of
“ nitre. It was scarce put in when a considerable
“ ebullition arose, with a very thick smoke. As I
“ found it continually increasing, and very fast
“ too, I retired a little, that I might observe the e-
“ vent without danger. This caution was not un-
“ necessary: for immediately the whole mixture
“ blew up as high as the cieling, with a noise like
“ the discharge of a musket, Nothing was left in
“ the vessel but a black matter, which still conti-
“ nued to boil a little and run over, and at last re-
“ mained very rare, spongy, and as full of holes
“ as a honeycomb: its consistence also was such
“ that it did not stick to my fingers when I hand-
“ led it.

“ As Mr. Geoffry, who first found the means
of

of firing the natural balsoms, observed in them a similar explosion on that occasion, it appears that my oil was very near taking fire in this experiment: which makes me presume that we may at last succeed in firing fat oils likewise, and consequently all others; seeing these have always been looked upon as the most unlikely to produce that phenomenon. I imagine that, to accomplish this, nothing more is necessary than to make use of sufficiently great quantities, and to order it so that the surfaces of the liquors, where they come into contact, may be of a large extent."

Afterwards, in 1747, Mr. Rouelle read before the academy a memoir on the accension of oils by acids. That memoir contains a great number of curious experiments, and peculiar manual operations described very distinctly, from which there results a general method of firing without fail, not only essential oils, but even any fat oil whatever: so that my conjecture, concerning the possibility of firing these latter oils, mentioned in my above-cited memoir of 1745, is now changed into a certainty. I shall proceed to explain how I conceive these accensions are brought about, and endeavour to account for the phenomenon from such causes as to me seem the most probable.

A due attention to the phenomena produced by mixing oils with acids will enable us, I imagine, to discover the natural cause why the oils take fire. It is certain, and demonstrated by the most decisive experiments, that the friction of several bodies rubbing against each other produces heat; and that when those bodies are combustible, and the heat produced by their friction rises to a certain degree, they take fire. This in my opinion, is what happens to oils when mixed with concentrated acids. When these two sorts of substances rush into union with rapidity, as in the experiments under consideration

ation, there must necessarily be a great friction among their parts. This friction produces the heat observed at the time of their union. The more concentrated the acids are, with the greater violence and rapidity do they act upon the oils, and the greater is the heat raised. If the acids be concentrated to such a degree as to produce, by uniting with the oils, a heat equal to that of an ignited body, the combustible substances that are exposed to it, which in this case are oils, must needs take fire and flame.

The heat produced on this occasion is so great, that, even when the inflammation doth not take place, if you touch the surface of the oil with your finger, as soon as the acid hath had its effect, you will find it burn you like a live coal.

Two pieces of wood, rapidly and violently rubbed against each other, take fire. What is it that is kindled in this case? It can be nothing but their oil: for they contain no other combustible principle. Why doth this oil take fire? I do not think it possible to assign any reason for it, but the heat produced by the friction of the pieces of wood containing the oil. If, when oil is dispersed in a body, of which it is only one component principle, and consequently mixed with many saline, aqueous, and earthy parts, that are not inflammable, but, on the contrary, make the oil less so, the oil nevertheless takes fire, and burns when agitated by a sufficient degree of heat; why shall not this very oil, when separated from the mixt of which it made a part, when united into one distinct mass, and entirely, or almost entirely, freed from the heterogeneous, incombustible parts with which it was combined, and consequently now more inflammable than before; why, I say, shall it not take fire, when exposed to a degree of heat equal, or rather superiour, to that which is produced by rubbing two pieces of wood together?

Let

Let us now examine the phenomena produced when oils are fired by acids, all the circumstances that favour or hinder their accension, and see if they agree with the explanation here offered.

First, no sort of oil will take fire with any acid whatever that is not highly concentrated; for weak acids act but feebly on oils, and dissolve them slowly; so that the friction is neither quick nor violent, and consequently produces too faint a heat, far below the degree of ignition.

Secondly, no inflammation is produced, when acids and oils are mixed in too small quantities; but the more acid and oil you mix together, the greater is the certainty of succeeding; for the heat is exactly in proportion to the friction that produces it; and the total quantity, or amount, of this friction is so much the greater, as there are more particles rubbing against each other at the same time. So that if a very small quantity of acid and oil be mixed together, there will be but a very small quantity of friction, and consequently a very small quantity of heat; and in that case no inflammation. It was with a view to avoid these inconveniences, and to procure the opposite advantages in as great a degree as possible, that in the passage above quoted from my memoir of oils, I proposed mixing together large doses of acid and of oil, as one of the means by which we might succeed in the accension of fat oils.

Thirdly, the figure of the vessel, in which the two liquors are mixed together, is not a matter of indifference. A wide spreading vessel, of a large diameter with respect to the quantity of liquor it is to contain, favours the inflammation much more than one of a small diameter. Nay, it may not succeed at all in too narrow a vessel, though all other circumstances may be properly attended to.

The reason of this is, that the activity of heat produced by friction is not in proportion to the successive

successive, but to the simultaneous frictions: for the heat actually produced by the frictions of an hundred particles, rubbing successively against each other, with intervals sufficient to let the heat go off, almost as fast as it is generated, would be equal to the friction of a single particle only; whereas the heat actually produced by the friction of the same number of particles, all rubbing against each other at the same instant, would be equal to the frictions of all the particles taken together, and consequently an hundred times more active than the other *. This being laid down, is is easy to conceive how a large vessel favours the accension more than a small one. It is certain that two liquors which mutually present large surfaces to each other, at the instant of their being mixed together, touch each other at one and the same time in a much greater number of points, than if each had but a small surface; and consequently that they must unite much sooner, and with greater rapidity, in the former case than in the latter.

With these views, and in order to give the liquors this advantageous disposition, I recommended it as what would greatly promote the inflammation of fat oils, to order the liquors so, that, at the moment of their mixture, a large surface of each might come into contact with the other.

Fourthly, if we reflect on the experiments hitherto made for kindling oils by acids, we shall

* I believe this proposition is not strictly true: for it appears to me, that, in order to make the heat, produced by the simultaneous frictions of an hundred particles, an hundred times more active than that produced by the successive frictions of the same number of particles, it is necessary that the simultaneous frictions should act all together in one point or center; which is impossible. But, as the particles that rub against each other, in the present case, are very near and contiguous, it is still true that the heat, resulting from their simultaneous frictions, is much more active than that produced by successive frictions only: which is sufficient for our present purpose.

It is easily be convinced that all oils are not equally apt to be fired; and that light, æthereal, very thin, essential oils do not produce this phenomenon so readily and so surely, as those of the same kind that are heavy and thick, or at least soon grow thick upon being mixed with acids.

Mr. Homberg says positively in the above-cited passage of his memoir, that he never could succeed in setting fire with the acid of vitriol to the white, æthereal oil of turpentine; that is, to the lightest which comes over first in distillation; but that the very same acid set fire to "that which comes over last in distillation, which is thick like a syrop, and of a dark-brown colour."

All the experiments by which oils have been fired, from those of Beccher and Borrichius, down to those of Geoffroy and Hoffman, were made on the essential oils of the aromatic plants of India, which are the heaviest we know, and on the empyreumatic oil of guaiacum, which, besides being very ponderous, is also very thick.

Now these singular effects likewise agree perfectly well with our explanation. It is certain that the parts of a heavy fluid do not yield to any impulse or shock, so easily as those of a lighter fluid; just as the parts of a thick, viscous fluid undoubtedly resist any attempt to separate them, so much the more the nearer the consistence of that fluid is to solidity, or the further it is removed from the state of fluidity. Now, the more resistance the acid meets with in separating and dividing the parts of the oil, as it must do to dissolve them, the more considerable will be the force and motion with which it must necessarily act to surmount those obstacles; besides, as experience teaches us that the density and viscosity of the oils do not, at least to some degree, diminish the quickness and activity which the acid exerts in uniting with them; the greater therefore must be the collisions, frictions, and heat produced;

duced : and this plainly shews why heavy, thick oils take fire, in this case, more readily than those which are fluid and light.

It may here be objected that fat oils, which are thicker and heavier than the light essential oils, take fire nevertheless with greater difficulty. This objection is easily answered, by observing that when we say acids fire heavy thick oils with more ease than thin light oils, this position must be restricted to oils of the same kind, on which acids have an equal, or nearly equal, action ; that is, to such oils as differ from each other in no other respect but their thickness and weight.

For example, Mr. Homberg, who could by no means set fire, with oil of vitriol, to the oil that rises first in the distillation of turpentine, found that the same acid would fire the oil that comes last over : and therefore it is reasonable to attribute his success, in firing this last oil, to its being thicker and heavier than the former ; seeing these two oils are in other respects of the same nature ; that acids have an equal action on both ; and that they differ from each other only in the qualities specified above.

But it is evident, that, if the oils compared together be of different kinds, and differ from each other, not only in weight and thickness, but also by containing different principles, or, at least, the same principles combined differently, and in different proportions, the action of any acid on those oils must also be different ; and that regard must be had thereto in determining their degrees of inflammability.

Now all this is applicable to fat oils, when compared with light essential oils, in point of inflammability. If all these oils were of the same nature, and differed from each other in weight and thickness only, the objection drawn from fat oils, which though thicker than essential oils do not
take

ake fire so easily, would be a very good one; and in fact would be against our reasoning. But this is far from being the case: the properties, as well as the analysis, of fat oils shew their nature to be very different from that of essential oils; that there is more water in their composition; and that they are full of a mucilaginous or gummy principle, which must greatly obstruct their inflammability, and the action of acids upon them.

None of the effects therefore, that attend the firing of oils with acids, is repugnant to our way of accounting for the phenomenon, which is one of the most beautiful in all natural philosophy. To conclude this important subject, nothing now remains but to consider the effects produced by the vitriolic acid in these accensions.

This acid, though of a stronger nature, and capable of being more highly concentrated than the nitrous acid, seems however less qualified to produce a flame with oils. Indeed Mr. Homberg fired oil of turpentine by mixing it with oil of vitriol: but I do not know that the experiment hath succeeded with any other chymist; on the contrary, most of those who have tried it affirm that they never could fire any oil with that acid alone.

Oils are probably in the same case as metallic substances, with regard to these two acids. We know that the nitrous acid dissolves those substances with vastly more activity and violence than the vitriolic acid exerts upon them; which may depend either on the disposition and configuration of their parts, or on the portion of phlogiston which, according to the opinion of most chymists, is united with the nitrous acid, is its peculiar characteristic, and the cause of the great vivacity with which it dissolves almost all matters that contain the phlogiston.

I say *almost* all matters that contain the phlogiston; because there are some substances that contain

tain a great deal thereof, and yet are not at all acted on by the pure nitrous acid. These substances are matters perfectly charred : that is, such as are capable of enduring the greatest violence of fire in close vessels, without yielding a single atom of oil ; that burn almost quite away, yet only grow red-hot without flaming ; or at least produce but a very small, slight flame, from which it is impossible to obtain the least particle of soot or fuliginosity ; in a word, that contain an inflammable matter, but such as is fit to be an ingredient in the composition of metallic substances, to which the peculiar title of the phlogiston is appropriated.

I say then that, if the nitrous acid be poured on a mere coal, perfectly charred, it is impossible for the acid, be it ever so highly concentrated, to set the coal on fire, though heated before to the greatest degree that it can possibly admit of without kindling ; and, which is still more remarkable, if a live coal be plunged into the most highly smoking spirit of nitre, it will be extinguished as if dipped in pure water.

But to return to the vitriolic acid : it is singular enough that this acid, which attacks oils with less activity, and for that reason seems less fit to set them on fire, than the nitrous acid, yet greatly promotes their accension, when mixed with that very acid. This may be owing to its rendering the oils with which it mixes heavier and thicker ; or else, as Mr. Rouelle conjectures with great probability, being more concentrated than the nitrous acid, and having a greater affinity with water, it dephlegmates the other, and thereby increases its activity ; or lastly, this may arise from some other cause yet unknown to us, and perhaps from that by which the acids of nitre and of sea-salt, which, when separate and perfectly pure, can neither of them dissolve gold, are enabled, when combined together,

together, to make a perfect solution of that metal.

P R O C E S S III.

To combine Essential Oils with Mineral Sulphur. Balsam of Sulphur. This composition decomposed.

PUT into a matrafs one part of flowers of sulphur; pour on them six parts of the essential oil of turpentine, for instance; set the matrafs in a sand-bath, and heat it gradually till the oil boil. The sulphur, which at first lay at the bottom of the matrafs, will begin to melt, and appear to dissolve in the oil. When it hath boiled in this manner for about an hour, take the matrafs from the fire, and let the liquor cool. A great deal of the sulphur that was dissolved therein will separate from it as it cools, and fall to the bottom of the vessel in the form of needles, much like a salt shooting in water.

When the liquor is perfectly cold, decant it from the sulphur that lies at the bottom of the vessel: to that sulphur put fresh oil of turpentine, and proceed as before: the sulphur will again disappear, and be dissolved in the oil: but when the mixture is cold, you will find new crystals of sulphur deposited at the bottom. Decant once more this oil from the crystals, and pour on fresh oil to dissolve them: continue the same method, and you will find that about sixteen parts of essential oil are required to keep one part of sulphur dissolved when cold. This combination is called *Balsamum Sulphuris Terebinthinatum*, if made with oil of turpentine; *Anisatum* if with oil of anise-seeds; and so of others.

OBSERVATIONS.

Essential oils do not dissolve sulphur, in such quantities, and with so much ease, as fat oils do. It was shewn above that a fat oil is capable of keeping a considerable quantity of sulphur in solution; whereas no less than sixteen parts of essential oil are required to dissolve one part only of sulphur, as in this process.

The property which sulphur hath of separating, in part, from the essential oil in which it is dissolved, and falling to the bottom of the vessel in the form of crystals, as the oil cools, proves that it is a kind a neutral salt, which, being insoluble in water because of the great quantity of inflammable matter that serves it for a basis, is not to be dissolved but by substances that actually contain themselves a great deal of inflammable matter; such as oils and metallic substances.

Though the latter are almost always solid, it nevertheless unites with several of them into regular forms, resembling saline crystals in every thing but pellucidity; as appears, for example, in several pyrites, antimony, and some other sulphureous minerals. But when it is dissolved in oils, especially in such as are capable of keeping but a small quantity thereof in solution, and consequently drop a good deal of it as they cool, it is precisely in the case of one of those salts whereof hot water dissolves more than cold; that is, the oil, that is saturated with as much sulphur as it can possibly take up when boiling hot, lets some part thereof precipitate as it cools; while the sulphur thus separated from the oil unites into little glebes of a regular figure, and actually chrySTALLIZES; in the same manner as nitre, when boiling water hath dissolved as much thereof as it can possibly take up, partly separates

separates from it when it cools, and falls to the bottom of the vessel in small crystalline *moleculæ*, of the form peculiar to that salt.

Mr. Homberg made some very curious experiments on this combination of sulphur with an essential oil. In the memoirs of the academy he gives the following analysis thereof.

“ Put your sulphur dissolved by oil of turpentine into a pretty large retort, because the matter puffs up towards the end, and distill with a very gentle heat for twelve or fifteen days and nights. There will come over about two thirds of the quantity of a colourless oil of turpentine, and at the same time a *pretty considerable quantity* of a whitish ponderous water, as acid as good spirit of vitriol. After this the drops of oil that come off will begin to be red. Then change your receiver, and increase the fire gradually; and in seven or eight hours time, with a very great heat, force off all that will rise, using a glass retort for your recipient. At last, most of the oil will come over into the receiver very thick and high-coloured, still accompanied with a whitish and very acid water. In the retort will be left a black *caput mortuum*, spongy, or foliated, shining and insipid. . . . This *caput mortuum* neither grows white, nor flames, nor wastes considerably in a strong fire.

“ The matter that comes over into the receiver must be distilled again, with a very gentle heat continued for several days and nights, in order to separate once more the colourless oil and the remaining acid water, till the oil begin to come off red. Then take the retort from the fire, and on the black gummy matter left in it pour good spirit of wine; mix the whole well together, and distill with a very gentle heat. When this spirit of wine is come off, pour some fresh on the black gum left in the retort, and distill as before.

Repeat

“ Repeat this till the spirit of wine cease to have a
“ bad smell.”

There is great reason to believe, that, by the union which the sulphur contracts with the oil, the cohesion of the acid and the phlogiston, which constitute that mineral, is considerably weakened; and that this is what occasions the decomposition of the sulphur so manifest in M. Homberg's analysis. The inflammable matter of the sulphur is so incorporated with that of the oil in the solution, that they form together one homogeneous whole; by which means the acid of the sulphur, which is of course dispersed through the whole liquor, is not now combined with the phlogiston, as it was in the sulphur before it was blended with the oil; that is, with the pure phlogiston; but with that phlogiston which constitutes the oily mixture, or, which is the same thing, with actual oil. And this is the reason that a composition of oil and sulphur yields, in distillation, nearly the same principles that a combination of the same oil with the vitriolic acid would yield.

We have already seen, under the head of fat oils, that when oils are combined with acids, if this combination be again decomposed by distillation, those two substances cannot be obtained in their original state; but that they are changed and partly decomposed. The case is the same in the experiment before us. We first get, by distillation, a pretty considerable quantity of oil of turpentine, that seems to have suffered no change at all. This first oil is that which the action of fire separates from the acid; and this it effects with so much the more ease that, a great quantity thereof having been necessarily used to dissolve a little sulphur, it greatly exceeds the quantity of acid in the mixture, and that the distillation is ordered to be made with a very weak degree of heat: for M. Homberg says it ought to be continued twelve or fifteen days and nights.

ights. Now this manner of distilling, with a very gentle heat, is the most effectual means of separating oils, especially light essential oils, from acids; because these oils rise in distillation with very little heat; whereas the acids, being much more ponderous, require a great deal more.

The oil that rises first in distillation appears indeed to be the same with that which was originally used in the mixture: but the quantity is much smaller: first, because some part of it, being combined with the acid of the sulphur, is thereby rendered thick and heavy, which hinders it from rising in this first distillation with a very gentle heat, and is the reason that it cannot be elevated without a much stronger degree of fire. It is this part that afterward comes over in the form of a red liquor upon encreasing the fire.

The second cause why the quantity of oil is lessened is, that part of it is decomposed in the operation. This decomposed part of the oil furnishes that considerable quantity of water which ascends at the same time with the oil, or a little after it, and serves for a vehicle to the acid that rises with it in this first distillation; which acid, though pretty strong, is now much more loaded with water than when it was an ingredient in the combination of sulphur. This acid water is of a milky white colour, because many oily particles are suspended and diffused in it, but not perfectly dissolved.

The *caput mortuum* that is left in the retort, after all the red thick oil is driven up by a very strong degree of fire, is a sort of charred matter, consisting of some of the earth of the sulphur, and of the decomposed oil, united with a phlogiston, which is probably furnished by both these substances. This matter contains also a little acid fixed with it. This acid re-produces sulphur, or at least becomes sulphureous, and flies off in vapours, when the coal is urged by a violent forge-heat: for

Mr.

Mr. Homberg observed that by this means it exhaled an odour of sulphur, and lost in weight.

This charred matter is of a singular nature : for, by being exposed to a forge-heat, and even to the heat in the focus of a burning glass, it seemed to suffer no other change than some loss of weight, occasioned by the evaporation of the acid effluvia carried off by the heat ; for it still retained its black colour, and was neither consumed nor vitrified. In order to melt it, Mr. Homberg was forced to mix it with borax. This salt converted it into a glass of a dark-grey colour : and, as there appeared a little verdegris on the surface of this glass after keeping it in a moist place, he thereby found that the sulphur he had used contained a little copper.

We know that the earth of copper is refractory, and that it communicates a dark colour to matters vitrified along with it : and perhaps it was the cause why the fixed matter in question retained its blackish colour so obstinately. notwithstanding the phlogiston that must have been in it at first was, in all probability, consumed by the violent ignitions it underwent.

As to the thick oily matter, called *gummy* by Mr. Homberg, from which he directs spirit of wine to be repeatedly distilled, till it cease to have a disagreeable smell, there is great reason for thinking it to be, as we said before, a portion of the oil which the acid hath rendered thick and heavy. The spirit of wine dissolves and carries up the most acid part, which always hath a disagreeable smell.

Mr. Homberg says that “ the part remaining
 “ after this, which he calls the *Gum of common sulphur*, hath a pleasant balsamic odour ; that it
 “ partly dissolves in spirit of wine, a hard resinous
 “ matter being left, which will not dissolve, either
 “ in spirit of wine, or in the strongest lixivium.”
 Of consequence therefore it is neither a resinous matter,

matter, nor a sulphur; "yet it dissolves perfectly in distilled oils." What then is this singular body? It is certainly a subject for very curious enquiries. In general, Mr. Homberg's whole process is full of interesting facts, and well deserves to be repeated, carried further, and carefully attended to.

PROCESS IV.

*To combine Essential Oils with Fixed Alkalis.
Starkey's Soap.*

TAKE salt of tartar, or any other alkali, thoroughly calcined. Heat it in a crucible till it be red, and in that condition throw it into a hot iron mortar: rub it quickly with a very hot iron pestle; and as soon as it is powdered pour on it, little by little, nearly an equal quantity of oil of turpentine. The oil will enter into the salt, and unite intimately with it, so as to form a hard paste. Continue rubbing this composition with the pestle, in order to compleat the union of the two substances; and, as your oil of turpentine disappears, add more, which will unite in the same manner, and give a softer consistence to the soapy mass. You may add still more oil, according to the consistence you intend to give you soap.

OBSERVATIONS.

Essential oils do not unite near so easily as fat oils with alkalis. For this reason, to make a soap with an essential oil, we must take a method different from that used in common soaperies. For if an essential oil be substituted for the fat oil, in the ordinary way of making soap, far from combining with the alkaline lixivium, though ever so strong, it

it will be wholly diffipated and vanish ; so that, after boiling some time, you will find nothing but the lye just as when first put in, only a little more concentrated.

The water, in which the alkali is dissolved when in the form of a lye, is the principal thing that hinders the salt from uniting with the essential oil. Water is such an enemy to this union, that, if the alkali be ever so little moist, the operation will not succeed ; even though all the other precautions mentioned in the process should be exactly observed.

In order therefore to free the alkali from all humidity, it is necessary to begin with making it red-hot ; and then, that this salt, which is very greedy of moisture, may not imbibe any from the air, before it be mixed with the essential oil, it must not be suffered to cool ; but the mixture must be made in a hot vessel, as soon as the salt is reduced to powder. When every particle of the salt is once covered with oil, you need not fear its attracting any moisture, at least very quickly, because the oil opposes its admission.

Starkey, the first chymist who found the means of making soap with an essential oil, and by whose name this kind of soap is therefore called, made use of a much more tedious method than that proposed in our process. He began with mixing a very small quantity of oil with his salt, and waited till all the oil united therewith of its own accord, so as to disappear entirely, before he added any more ; and thus protracted his operation exceedingly, though in the main it was the same with ours. The method here proposed is more expeditious, and was invented by Dr. Geoffroy.

Starkey's soap dissolves in water much as common soap does without any separation of the oil ; and by this mark it is known to be well made. It may also be decomposed, either by distillation,
or

or by mixing it with an acid : and its decomposition, in either of these ways, is attended with nearly the same phenomena as the decomposition of common soap.



C H A P. VI.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY MEANS OF A GRADUATED HEAT, FROM THAT OF BOILING WATER, TO THE STRONGEST THAT CAN BE APPLIED TO THEM IN CLOSE VESSELS.

P R O C E S S I.

To analyze Vegetable Substances that yield neither a Fat nor an Essential Oil. Instanced in Guaiacum-Wood.

TAKE thin shavings of guaiacum-wood, and put them into a glass or stone retort, leaving one half thereof empty. Set your retort in a reverberating furnace, and lute on a large glass receiver having a small hole drilled in it ; such as is used for distilling the mineral acids. Put a live coal or two in the furnace, to warm the vessels gently and slowly.

With a degree of heat below that of boiling water, you will see drops of a clear insipid phlegm fall into the receiver. If you raise the fire a little, this water will become slightly acid, and begin to have pungent smell. With a degree of fire somewhat stronger, a water will continue to rise which will be still more acid, smell stronger, and become yellowish. When the heat comes to exceed that of boiling

boiling water, the phlegm that rises will be very acid, high coloured, have a strong pungent smell, like that of matters long smoaked with wood in a chimney, and will be accompanied with a red, light oil, that will float on the liquor in the receiver.

And now it is necessary that the operation be carried on very cautiously, and vent frequently given to the rarefied air by opening the small hole in the receiver; such an incredible quantity thereof rushing out of the wood, with this degree of heat, as may burst the vessels to pieces, if not discharged from time to time.

When this red, light oil is come over, and the air ceases to rush out with impetuosity, raise your fire gradually, till the retort begin to redden. The receiver will be filled with dense vapours; and together with the watery liquor, which will then be extremely acid, there will rise a black, thick, ponderous oil, which will fall to the bottom of the receiver, and lye under the liquor.

Then give the utmost degree of heat; that is, the greatest your furnace will allow, and your vessels bear. With this excessive heat a little more oil will rise, which will be very ponderous, as thick and black as pitch; and the vessels will continue full of vapours that will not condense.

At last, when you have kept the retort exceeding red for a long time in this extremity of heat, so that it begins to melt, if it be of glass, and you perceive nothing more come over, let the fire go out and the vessel cool. Then take off your receiver: from the black oil at bottom decant the acid liquor with the red oil floating on it, and pour them both into a glass funnel, lined with brown filtering paper and placed over a bottle. The acid liquor will pass through the filter into the bottle, and the oil will be left behind, which must be kept by itself in a separate bottle. Lastly, into another funnel, prepared as the former, pour the thick oil remaining
with

with a little of the acid liquor at the bottom of the receiver. This liquor will filter off in the same manner, and thus be separated from the heavy oil.

In the retort you will find your guaiacum shavings, not in the least altered as to their figure, but light, friable, very black, scentless, and tasteless, easily taking fire, and consuming without flame or smoke; in short you will find them charred to a perfect coal.

OBSERVATIONS.

Hitherto we have examined the substances that may be obtained from vegetables, either without the help of fire, or with a degree of heat not exceeding that of boiling water. The analysis of plants can be carried no further without a greater degree of heat: for, when the principle of odour, and the essential oil of an aromatic plant, are wholly extracted by the preceding processes, if the distillation be afterward continued without increasing the heat, nothing more will be obtained but a little acid; which will soon cease, as a small part only of the quantity contained in the plant will be elevated; the rest being either too ponderous, or too much entangled with the other principles of the body, to rise with so small a degree of heat.

In order therefore to carry on the decomposition of a plant, from which you have, by the methods before proposed, extracted all the principles it is capable of yielding when so treated; or, which comes to the same thing, in order to analyze a vegetable matter, which affords neither an expressed nor an essential oil, it must be distilled in a retort with a naked fire, as directed in the process, and be made to undergo all the degrees of heat successively, from that of boiling water, to the highest that can be raised in a reverberating furnace.

A heat inferiour to that of boiling water, with

which we must begin in order to warm the vessel gradually, brings nothing over, as hath been said, but an insipid water, destitute of all acidity. By increasing it nearly to the degree of boiling water, the distilled water comes to be slightly acid.

When the heat is made a little stronger than that which is necessary for the elevation of an essential oil, the acidity of the water that comes off is much more considerable. It hath now both colour and smell, and there rises with it a red, light oil, that floats on the liquor in the receiver. This is not an essential oil; it hath none of the odour of the plant. Though so light as to float on water, yet it will not rise with the degree of heat that raises essential oils; even those that much surpass it in gravity, and will not swim on water as this does. This proves that the ease or difficulty, with which a particular degree of heat raises any substance in distillation, doth not depend altogether on its gravity: its dilatability, or the volatile nature of the matters, with which it is so closely united as not to be separated from them by distillation, may probably contribute greatly to produce this effect.

It is very surprising that a substance so hard, so compact, so dry, in appearance, as guaiacum-wood, should yield such a large quantity of water by distillation; and it is equally so that it should discharge so much air, and with so much impetuosity, as nothing but experience could render credible. We have, in the process, directed the precautions to be taken when this air, from being prodigiously condensed in the body of which it made a part, is set at large, rushes out of confinement, and expands with all its natural elasticity. From this air arises the greatest danger attending the operation.

It hath been remarked that the heaviest and most compact woods yield the most air in distillation: and accordingly guaiacum-wood, which we have chosen for an instance, as exceeding almost all others

thers in hardness and weight, discharges a vast quantity of air when analyzed.

The thick, burnt, empyreumatic oil, that comes over last in this distillation, is heavier than water; on account, probably, of the great quantity of acid with which it is replete. The two kinds of oil obtained in this analysis may be rectified, by distilling them a second time, or rather several times; by which means they will become lighter and more fluid, as we have seen happen to fat and essential oils. In general, all thick, heavy oils constantly owe these qualities to an acid united with them; and it is by being freed from some of that acid in distillation, that they always acquire a greater degree of lightness and fluidity from that operation. To these laws all vegetable oils are subject, of what nature soever they be.

The analysis of a vegetable substance, exhibited above, shews what may be obtained from them, when distilled in close vessels, with a graduated heat, from that of boiling water, to that which converts the mixt to a perfect coal; viz. phlegm, an acid, a light oil, much air, and a thick oil. But this analysis is far from being a complete one: it may be carried much farther, and made more perfect.

None of the principles obtained by this analysis are pure, simple, and thoroughly separated from the rest. They are still in some measure blended all together: their separation is but begun; and each requires a second and more accurate analysis, to reduce it to the greatest degree of purity of which it is capable. The oil and the acid chiefly merit so much pains.

A great deal of the acid of the plant remains, as was said, combined with the two sorts of oil here obtained; which we have reason to think differ no otherwise from one another, than as there is more or less acid united with each. The best way of freeing these oils from their redundant acid is to

distill them frequently from alkalis and absorbents. Some of our best Chymists have taken this pains with several sorts of oils; but the method might be still extended, and the operation carried further than hath yet been done.

The acid is in the same circumstances nearly as the oil. The first that rises is mortified with much water, to which it owes a good deal of its volatility. That which comes over last is much more concentrated, and consequently heavier; yet it is still very aqueous. It might be freed in a great measure from this adventitious water, and so rendered much stronger; which would give us a better opportunity to discover its nature and properties, of which we know but very little.

Water is not the only heterogeneous substance that disguises the vegetable acid: a pretty considerable quantity of the oil of the plant is also combined with it, and contaminates its purity. The proof of this is, that, when these acids are kept, in the same condition in which they first come over, for any length of time, in a glass vessel, they gradually deposite, on the bottom and sides of the vessel, an oily incrustation, which grows thicker and thicker the longer it stands; and, as this oily matter separates from it, the acid liquor appears less unctuous and saponaceous.

A very good way to separate this oil more effectually from the acid is to combine the whole with absorbents; and abstract the oil again by distillation. By this means a very sensible quantity of oil may be separated that was not perceived before. On this occasion it is proper to remark that the oil thus united with the vegetable acid is perfectly dissolved by it; seeing it is thereby rendered miscible with water, so that it doth not, like alkaline soaps, in the least obscure its limpidity, or gave it a milky cast: for these aqueous, oily acids are very transparent; especially after they have stood for some time.

The

The air, that is discharged with impetuosity in the operation, and must be let out, is loaded with many particles of acid and oil reduced to vapours, which it carries off; and by this means the quantity of the principles extracted from the mixt cannot be accurately determined: nor are the vapours, of which the vessels remain full after the operation, any other than particles of acid and oil, which the violence of the fire hath rarefied exceedingly, and which do not easily condense.

If we distill in this manner a vegetable aromatic substance, which of course contains an essential oil, provided it hath not been previously extracted by the appropriated process, this essential oil will rise first, as soon as the distilling vessel acquires the heat of boiling water: but its scent will not be near so sweet or grateful, as if it were distilled in the manner before directed as properest for it. On the contrary, it will have an empyreumatic smell: because in this way it is impossible to avoid scorching, and half-burning some of the matter distilled; especially that part of it which touches the sides of the retort. Moreover, the very same equable degree of heat can hardly be kept up with a naked fire. The essential oil therefore, though it rises first, will not be pure, but contaminated with a mixture of the empyrenmatic oil that first comes over, and will be confounded therewith.

If a substance abounding with fat oil, that hath not been expressed from it, be distilled according to the present process, it will yield no fat oil by distillation; but only much more of the first clear oil, and of the second thick oil, than if all the fat oil it would have afforded had been first drawn off by expression: for as the fat oil will not rise in distillation, without a degree of heat greater than that of boiling water, neither can it endure such a degree of heat without changing its nature, without losing that mildness, and, in a great measure, that unctuousity

unctuosity which is natural to it. It will therefore be confounded with the other empyreumatic oil, which, in all probability, would itself be no other than a fat oil, if it could be wholly extracted, without the aid of fire, from the vegetable substances containing it.

Most vegetables substances, when distilled with a strong fire, yield the same principles with that which we have chosen for an instance. Entire plants of this kind, those from which the odorous principle, the essential oil, or the fat oil, hath been drawn, those of which extracts have been made by infusion or decoction, or the extracts themselves; all such matters being distilled yield a phlegm, an acid, a thin oil, air, and a thick oil; and the products of their several analyses differ from each other, only on account of the different quantity or proportion that each contains of the principles here enumerated.

But there are many other plants, which, besides these substances, yield also a considerable quantity of a volatile alkaline salt. This property is possessed chiefly by that tribe of plants which is distinguished by having cruciform flowers; among which there are some that being analyzed greatly resemble animal matters. We shall now analyze one of these; mustard-seed for instance.

P R O C E S S II.

To analyze a Vegetable Substance which yields the same principles as are obtained from Animal matters: instanced in Mustard-seed.

WITH an apparatus like that of the preceding process, and with the same fire, distill mustard-seed. With a degree of heat, inferiour to that of boiling water, there will come over a phlegm somewhat coloured, and impregnated with a volatile

le alkaline salt. With a degree of heat, greater than that of boiling water, the same kind of phlegm impregnated with the same salt, will continue to come over; but it will be much higher coloured, and will be accompanied with a light oil. At this time a considerable quantity of air is discharged; with regard to which the same precautions must be taken as in distilling guaiacum.

If the fire be gradually raised, there will come over a black thick oil, lighter however than water; and at the same time vapours will rise, and, condensing on the sides of the receiver, form into sprigs or ramifications. This is a volatile alkaline salt, in a concrete form, like that of animals, as we shall hereafter see. These vapours are much whiter than those of guaiacum.

When you have thus drawn off, with a very strong fire, all the volatile alkali and thick oil contained in the subject, there will be nothing left in the retort but a sort of coal, from which a small quantity of phosphorus may be obtained, provided the retort you employ for that purpose be good enough to stand a very violent heat.

OBSERVATIONS.

Mustard-seed furnishes us with an instance of a vegetable, from which we obtain, by analyzing it, the very same principles that animal matters yield. Instead of getting an acid from it, we obtain only a volatile alkali; probably because the acid, which originally enters into the composition of this kind of vegetables, as well as of all others, undergoes in passing through their strainers, and mixing with their juices, such alterations as it suffers when it enters into the composition of animals: that is, it combines with some of their earth and of their oil, in such a manner as to be changed into a volatile alkali

kali, or at least disposed to be connected into one with the aid of fire.

We shall not here speak of the manner of separating and depurating the principles obtained by this process ; but reserve it for the analysis of animals, which is absolutely the same. We shall content ourselves with observing that the first volatile alkali which rises at the beginning of the operation together with the phlegm, in a degree of heat below that of boiling water, differs from that which doth not come over till towards the end of the distillation, when the last thick oil ascends. The different times, and different degrees of heat, in which these two alkalis rise, shew that the former exists actually and perfectly in the plant ; but that the latter is generated during the distillation, and is the product of the fire, which combines together the materials whereof it is composed.

Vegetables, that thus yield a volatile alkali with a heat less than that of boiling water, irritate the organ of smelling, affecting it with a sensation of acrimony ; and the effluvia, which rise from them when bruised, make the eyes smart so as to draw tears from them in abundance. Several of these matters, being only bruised, effervesce with acids : effects producible only by a very volatile alkaline principle,

This is that alkali, the lightest of all the principles that can be extracted from bodies, which rises first in our distillation along with the phlegm, and with a degree of heat much inferiour to that of boiling water. As the phlegm with which it rises is very copious, it is dissolved thereby ; which is the reason it doth not appear in a concrete form. To this water it gives a slight yellowish tinge, because it is impure and oily. The saline alkaline properties of this liquor have procured it the title of a volatile spirit. This volatile alkali, which exists naturally and perfectly formed in mustard seed, onions, garlick,

garlick, cresses, and other such vegetables, constitutes a difference between them and animal substances, which contain only the materials requisite to form a volatile alkali, but none ready formed, unless they have undergone the putrid fermentation.

The second volatile alkali, which rises in our distillation, but not without a very strong degree of fire, and at the same time with the last thick oil, seems to be a production of the fire; for if it were already formed in the mixt, as the other is, it would rise with the same heat, and at the same time, being equally volatile. It is not impossible however, that it may exist perfectly formed in the plant; but having contracted an union with some acid, and therewith composing an ammonical salt, it may by that means be hindered from rising so readily as is agreeable to its natural volatility.

The phosphorus obtained by a violent fire, from the *caput mortuum* of this distillation, seems to throw a light of probability on this conjecture. There is certainly a great deal of acid in the composition of phosphorus. Perhaps this acid was originally combined with our second volatile alkali, and formed therewith, as was said, a sort of sal ammoniac. Moreover, almost all the plants, that yield a volatile alkali by distillation, yield also a considerable quantity of acid: which may perhaps be the remains of such a sal ammoniac decomposed by the operation. This is a subject for curious and useful enquiries. This second volatile alkali appears in a concrete form, because very little phlegm comes over along with it; so that the vapours thereof are not sufficient to dissolve it, as they did the first.



C H A P. VII.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY COMBUSTION.

P R O C E S S I.

To procure a Fixed Caustic Alkaline Salt from a Vegetable Substance, by burning It in the open Air.

TAKE any vegetable matter whatever ; set it on fire, and let it burn in the open air till it be wholly reduced to ashes. On these ashes pour a quantity of boiling water sufficient to drench them thoroughly. Filter the liquor in order to separate the earthy parts ; and evaporate your lye to dryness, stirring it incessantly ; and you will have a yellowish-white salt.

Put this salt in a crucible ; set it in a melting furnace, and make a moderate fire, so as not to fuse the salt. It will turn first of a blue grey colour, afterwards of a blue-green, and at last redish. Put on the dome of the furnace ; fill it with coals ; make your fire strong enough to melt the salt, and keep it in fusion for an hour, or an hour and half. Then pour it into a heated metal mortar ; pound it while it is red-hot ; put it, as soon as possible, into a glass bottle, first made very hot and dry, and shut it up close with a glass stopple rubbed with emery. By this means you will have the pure fixed alkali of the vegetable substance you burnt.

O B S E R.

OBSERVATIONS.

Burning a vegetable substance in the open air is a kind of violent and rapid analysis made by fire, which separates, resolves, and decomposes several of its principles.

When any wood or plant is laid on a quick fire, there ascends from it immediately an aqueous smoke, which consists of little more than phlegm, but this smoke soon becomes thicker and blacker: it is then pungent, draws tears from one's eyes, and excites a cough if drawn into the lungs with the breath. These effects arise from its being replete with the acid, and some of the oil, of the vegetable converted into vapours. Soon after this the smoke grows exceeding black and thick: it is now still more arid, and the plant turns black. Its strongest acid and last thick oil are now discharged with impetuosity.

This rarefied oil being heated red-hot suddenly takes fire and flames. The vegetable burns and delagrates rapidly, till all its oil is consumed. Then the flame ceases; and nothing remains but a coal, like that found in a retort after all the principles of the plant have been extracted by the force of fire. But this coal having a free communication with the air which is absolutely necessary to keep a combustible burning, continues to be red, sparkles, and wastes till all its phlogiston is dissipated and destroyed. After this nothing remains but the earth and fixed salt of the vegetable; which mixed together form what we call the ashes. Water, which is the natural solvent of salts, takes up every thing of that kind that is contained in the ashes; so that by lixiviating them, as directed, all the salt is extracted, and nothing left but the pure earth of the mixt which is thus decomposed.

The phenomena observed in the burning of a vegetable substance, and the production thereby of a

fixed alkali, seem to prove that this salt is the work of the fire; that it did not exist in the plant before it was burnt; that the plant only contained materials adapted to form this salt; and that this salt is no other than a combination of some of the acid, united with a portion of earth, by means of the igneous motion.

In the first place; a fixed alkali may be obtained by lixiviation from the ashes of all vegetable matters that contain an acid, earth, and phlogiston, in due proportion. Thus essential salts; the substance of extracts made by trituration, infusion, or decoction; wood coals burnt to ashes; all yield a quantity of this salt in proportion to the quantity of acid and earth contained in them.

Secondly; fat, essential, and empyreumatic oils afford, when burnt, such a small quantity of fixed alkali as is scarce perceptible; because they contain but little acid, and still less earth: and these same oils, when rectified by repeated distillations, and then burn, leave still less of this salt; because they are separated by rectification from most of the acid, together with the small matter of earth contained in them.

Thirdly: those vegetable matters which being analyzed furnish a great deal of volatile alkali, yield but very little fixed alkali; because a great deal of their acid is employed in forming the volatile alkali, which is dissipated by burning the plants: and for the same reason those which in distillation afford only a volatile alkali, and no acid, leave in their ashes little or no fixed alkali, as is also the case with animal matters.

Fourthly, and lastly; the ashes of such plants as have been long steeped in water, and from which infusions and decoctions have been made, always contain the less alkali the longer they have been infused or boiled, and the more water they were infused or boiled in; because water dissolves and carries

carries off their acid. It is for this reason that the ashes of float-wood are much less saline than those of green wood. Boerhaave assures us, in his chymistry, that having exhausted rosemary by repeated decoctions, and having afterwards boiled the plant thus treated, the ashes produced by it shewed not the least sign of a fixed alkali. He says that, in order to exhaust thoroughly all the saline matters contained in rosemary, he was obliged to decoct it no less than twenty times successively, with fresh water every time, and never ceased boiling it in this manner, till he was sure that the water, by boiling the plant in it for a long time, took up from it no kind of matter whatever that in the least affected its purity: so that the water of his last decoction had absolutely no smell, taste, or colour; but was in short precisely the same as before he used it for the decoction. The same author observes that his plant, after having been exhausted in this manner, and having suffered such continued boiling, retained nevertheless its perfect external form; that from being green at first it became brown, and sunk to the bottom of the water, instead of floating thereon as it did before decoction.

If, in re-iterating this beautiful experiment of Mr. Boerhaave's, you should not succeed as you expect, you must not therefore accuse this great man of having been mistaken on this occasion; seeing it is very difficult, not to say impossible, to ascertain exactly, from the account he hath given of his experiment, all that is necessary to its perfect success: for he hath not specified either the duration of the coctions which he made the rosemary undergo, or the quantity of water he employed in each; whereas a difference in either of these may occasion a vast difference in the result. It is evident, that if five or six pounds of water be used for each coction of a pound of rosemary, and be kept

boiling for two or three hours, the plant will not be near so much exhausted by being so treated, as if the the same quantity thereof were kept boiling for several days in forty or fifty quarts of water.

Indeed, these points seem, in some measure to be determined, by what he says of the quality which the water of the last decoction ought to have. But the same objections occur here also; nay, the two circumstances of the quantity of water and the duration of the boiling, have the greatest influence here: for the more a plant is exhausted of its salts, the more difficult it becomes for the water to dissolve and separate the small quantity thereof that remains united with the tenacious oil; and consequently it may happen that this last water, after the plant hath boiled in it five or six hours, shall appear insipid, scentless, colourless; and yet that a much greater quantity of water, but reduced by longer boiling to the same quantity with that which hath been boiled but five or six hours, shall have acquired both taste and colour; in a word, shew that it hath taken up some of the principles of the plant. It may also happen, that, a small portion of saline matter being diffused through a large quantity of water, after long continued coction, shall not be perceptible either to the taste or to they eye; but that the very same portion of saline matter shall become very sensible, when the quantity of water in which it is lost, as it were, is sufficiently lessened by evaporation.

Hence, if we would make sure of fulfilling the conditions acquired by Mr. Boerhaave, the last decoction of the plant must be made in a much greater quantity of water, and continued for a much longer time, than may perhaps be imagined, or perhaps easily determined; and this decoction being evaporated to any degree you please, must have neither taste, smell, nor colour: In short, it must
from

from first to last remain perfectly like pure water. In other words, it is very difficult to attain to any certainty in this matter.

Though what hath hitherto been said, about procuring fixed alkali of plants by combustion, seems to prove that this salt is wholly the production of the fire, yet it must not be asserted that no part thereof pre existed formally in the plant before it was burnt. On the contrary, it is certain that, amongst the saline matters found in the composition of plants, there are true neutral salts whose basis is a fixed alkali; but this alkali being combined with an acid discovers none of its properties, and never appears in its true form till the neutral salt of which it makes a part is decomposed by combustion. The case of sea plants, all of which contain sea-salt, and when burnt yield an alkaline salt perfectly resembling the basis of sea-salt, seems to decide this point.

If, in lixiviating the ashes of a plant, to dissolve and wash out its alkali, you intend that nothing should be left but an absolutely pure earth, fit for making cupels, you must not be contented with one oblation only, even with a large quantity of water; because the ashes continue drenched with the water in which the salts are dissolved, and consequently, when this water is evaporated, some of the salts will be left with the earth. Therefore, if this be your view, you must wash it three or four several times, using fresh water every time.

The water impregnated with the alkali cannot be evaporated without a considerable loss of salt, especially if it be volently boiled; because the water, with which it is closely united, carries off part of it. In consequence of this intimate union, it is very difficult, when the evaporation is near finished, and but a little water left, to dry the salt perfectly, because it pertinaciously retains this last portion of humidity.

The alkali obtained from the ashes of a burnt plant is not perfectly pure : it is contaminated with a small mixture of fatty matters, which were probably defended thereby against the action of the fire, and which render it somewhat saponaceous. In order to free it from this extraneous matter, and to render it very caustic, it must be calcined a long time in a crucible, but without melting it at first : because it is with this salt as with most metallic matters, which are sooner and more easily deprived of their phlogiston by being calcined without melting, provided they be comminuted into small particles, than when they are in fusion ; all melted matters having but a small surface exposed to the air, by the contact of which the evaporation of any thing whatever is exceedingly promoted. It was for this reason we directed the salt to be calcined for a long time in a crucible before melting it.

Mr. Boerhaave was very sensible of the utility of this calcination of the alkali previous to its being melted, when in his Chymistry he ordered the ashes containing this salt to be put into a large earthen vessel, kept red-hot for a considerable time, taking great care that the salt do not melt. He takes notice, that, the longer the ashes are calcined in this manner, the stronger is the alkali obtained from them. This method is, in the main, the very same with that here prescribed, and produces the same effect ; because the alkali is equally well freed of the extraneous fatty matter, whether it be calcined before or after its separation, provided it be not suffered to melt.

Mr. Boerhaave gives another reason for recommending care to be taken that the fixed alkali do not melt, while the ashes are calcining to render it stronger and more caustic : for, if that should happen, the melted mixture of the salt and ashes would produce a vitrified mass, which would have none of the properties of the salt.

P R O C E S S II.

To procure the Fixed salt of a Plant, by burning it after the Manner of Tachenius,

INTO an iron pot put the plant whose salt you desire to obtain in the manner of Tachenius, and set it over a fire, strong enough to make its bottom red hot; at the same time cover your plant with a plate of iron, that may lye immediately upon it in the pot. The plant may grow black, and smoke considerably; but will not flame, because it hath not a sufficient communication with the air. The black smoke only escape through the interstice left between the side of the pot and the rim of the plate; which, for that purpose, should be made so as not to fit exactly into the pot. From time to time take up the iron plate, stir the plant and cover it again immediately, to prevent its taking fire, or to smother it if it should happen to flame; go on thus till the black smoke cease.

Then take off the iron plate: the upper part of the half-burnt plant will take fire as soon as the air is admitted, consume gradually, and be reduced to a white ash. Stir your matter with an iron wire, that the undermost parts, which are still black, may be successively brought uppermost, take fire, and burn to white ashes. Go on thus as long as you perceive the least blackness remaining. After this, leave your ashes some time longer on the fire; but stir them frequently, to the end that, if any black particles should still be left, they may be entirely consumed.

Your ashes being thus prepared lixivate them with seven times their quantity of water, made to simmer over the fire, and keep stirring it with an iron ladle. Then filter the liquor, and evaporate it to dryness in an iron pot, stirring it incessantly towards

towards the end, lest the matter, when it grows stiff, should adhere too closely to the vessel. When all the humidity is evaporated, you will have a salt of a darkish colour, and alkaline nature; which you may melt in a crucible, and mould into cakes. This is the fixed salt of plants, prepared in the manner of Tachenius.

OBSERVATIONS.

The fixed salt obtained from plants in the manner invented by Tachenius, and here described, is in many respects different from the caustic fixed alkali extracted out of the ashes of plants that have been consumed by flaming in the open air. Tachenius's salt is indeed of an alkaline nature; but much weaker than a pure fixed alkali. It is not by far so caustic; it attracts the moisture of the air much more feebly and slowly; it melts with a much smaller degree of heat; and it doth not make so strong an effervescence with acids. In short, if you dissolve it in water, evaporate the solution to a pellicle, and set it in a cool place, it will shoot into small crystals; which is not the case with a pure fixed alkali.

These several different effects, which characterize Tachenius's salt, and distinguish it from the caustic fixed alkali produced by burning a plant in the open air, prove that it is not a pure alkali, but combined with certain substances that bring it nearer to the nature of a neutral salt, and place it, as it were in the mid-way between such a salt and a true alkali. If we reflect on the manner in which it is produced it is easy to perceive what those substances are that must be combined with it. It hath been shewn that plants, when analyzed, yield a great deal of oil and of acid. When they are burnt in the open air, all their oil is dissipated in smoke, or consumed in flame. Great part of the acid is likewise
dissipated

diffipated, and the remainder combining with the earth of the plant forms a fixed alkali.

When the same plants are analyzed, by distilling them in close vessels, the same principles are carried up by the action of the fire, forced to separate from the fixed parts, and pass over into the receiver in the form of vapours and of a liquid: but, when they are burnt in the manner of Tachenius, the acid and oil of the plant, as fast as they are expelled by the action of the fire, are repelled by the iron cover, which at the same time that it prevents the oil from being entirely consumed in flame, obliges these two substances to circulate, reverberates them on the rest of the plant, and, in a manner, forces them to re-unite, in a part, with that from which they were just before separated.

A considerable quantity, therefore, of the oil and acid of the plant, must evidently combine. in this operation, with its fixed salt, as fast as it is produced: and the properties above specified are owing to these two substances. Tachenius's salt is, therefore, a fixed alkali, partly neutralized by some of the acid of the plant, and rendered a little saponaceous by a portion of its oil; whence it is much milder than a pure fixed alkali, and proper to be given internally, as an excellent remedy in several disorders.

For the medicinal virtues of this salt Mr. Boerhaave's Chymistry ought to be consulted, as the Author was a very good judge of such matters.

Tachenius's salt may be converted into a caustic fixed alkali, by freeing it from the acid and from the oil to which its peculiar properties are owing. For this purpose nothing more is requisite than to calcine it for a long time in a crucible, stirring it frequently with an iron wire, and taking care not to melt it, till it have undergone the same changes, and successively acquired the same colours, as our fixed

fixed alkali; and, when it becomes redish, melting it and keeping it in fusion for an hour or two.

Hitherto no sensible difference hath been observed between the caustic fixed alkalis obtained from different plants, when equally calcined; except that those produced by sea-plants have, as we said before, the same properties as the alkaline basis of sea-salt. Much the same thing may be said of the fixed salts obtained from plants by Tachenius's method: for, though they combined with a portion of the acid and oil of the plant, yet, as these principles have been exposed to the action of a strong fire, they are exceedingly altered, and almost wholly reduced to one and the same condition.

P R O C E S S III.

*To render Fixed Alkalis very caustic by means of Lime.
The Caustic Stone.*

TAKE a lump of newly burnt quick-lime, that hath not yet begun to flake in the air: put it into a stone pan, and cover it with twice its weight of the unwashed ashes of some plant, that are full of the salt you design to render caustic. Pour on them a great quantity of hot water; let them steep in it five or six hours, and then boil them gently. Filter the liquor through a thick canvas bag, or through brown filtering paper supported by a linen cloth.

Evaporate the filtered liquor in a copper basin set over the fire; and there will remain a salt, which must be put into a crucible set in the fire. It will melt, and boil for some time; after which it will be still, and look like an oil, or melted fat. When it comes to this condition, pour it out on a very hot copper-plate, and cut it into oblong tapering slips, before it grow hard by cooling. Put these
slips,

slips, while they are still hot, into a very dry glass bottle, and seal it hermetically. This is the *caustic stone*, or *common caustic*.

OBSERVATIONS.

The design of this operation is to combine with the fixed alkali all the saline acrid parts of the quick-lime. This is to be effected only by dispersing and diffusing both those substances in water, which is the proper solvent of all saline matters. Seeing, therefore we must have an actual lixivium, it is needless to employ an alkali already prepared and separated from ashes; for which reason we directed ashes that are still replete with alkali to be used instead of a pure alkali. By this means two ends are answered at once: the salt contained in the ashes is extracted from them, and combined with the most acrid, subtile, and saline parts of the lime.

The lye, when saturated with these two saline matters together, is vastly more acrid and caustic than if it contained but one of the two in a quantity equal to both. With this lye soap is usually made; because the acuated alkali contained in it hath a much greater effect on oils than any other kind of alkali. It also acts with incredible violence on all animal matters; which it dissolves, divides, and, in some measure, destroys, with surprising efficacy and quickness.

For this reason it is impossible to filter it through a woollen or filken bag; for it will eat holes in them, or even reduce them to a pap, almost as soon as it touches them. Besides, as the lye would dissolve some part thereof, it would thence acquire a saponaceous quality, and so lose much of its caustic nature. We must, therefore, necessarily use a filter made of vegetable matters, which resist this destroying salt much better than animal matters.

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An alkali thus acuated by quick lime attracts and retains humidity more strongly than any other kind of alkali, even the perfectest and best calcined. For this reason it is almost impossible to dry it thoroughly in the bason wherein you evaporate the lixivium.

To the moisture still left in it must be attributed its boiling when it begins to melt in the crucible. When all the humidity is dissipated, the fused salt remains smooth and unruffled, like wax melted with a gentle heat.

This caustic salt is vastly more fusible than the common alkalis. It scarce grows red before it flows like wax. When it is once in quiet fusion, all the humidity that occasioned the boiling observed at first being dissipated, it is as caustic as it can be made. It is then time to pour it out, and to cut it into long narrow sticks, fit for the use of surgeons, who apply it to eat away callosities and excrescences and to open issues. On this account it is called the *caustic stone*. The operation of this salt is so quick, that, in a very short time, it produces on the skin a sensation like that of fire.

As this salt grows surprisngly soon moist in the air, and loses its virtue when so moistened, it is necessary to shut it up, while it is still hot, in a very dry bottle, which must be immediately stopped with a glass stopple rubbed with emery, or else with a sound cork and then dipt in pitch. In spite of all these precautions, it can scarce be kept five or six months in full vigour; especially if the bottle be sometimes opened in the mean while. We shall not attempt to explain here why an alkali becomes so violently caustic by being combined with quicklime. This question seems to be one of the most subtle, and the most difficult to answer, in all Chymistry. It depends on the cause of the alkaline properties of lime; and can hardly be resolved, till we

we attain a further insight into the nature of that substance than we have yet got,

PROCESS IV.

The Analysis of Soot.

TAKE wood-foot from a chimney under which no animal matter hath been dressed or burnt: put it into a glass retort set in a reverberating furnace; lute on a receiver, and begin to distill with a degree of heat somewhat less than that of boiling water. A considerable quantity of limpid phlegm will come over. Keep the fire in the same degree as long as any of this phlegm rises; but encrease it when the drops begin to come flow: and then there will ascend a good deal of a milky water. When this water ceases to run, change the receiver, and increase your fire a little: a yellow volatile salt will rise, and stick to the sides of the receiver. The fire ought now to be very fierce, and, if so, will force up at the same time a very thick black oil. Let the vessels cool: you will find a saline matter risen into the neck of the retort, which could not pass over into the receiver: in the bottom of the retort will be a *caput mortuum*, or black charred substance, the upper part of which will be cruisted over with a saline matter, like that in the neck of the retort.

OBSERVATIONS.

The preceding analysis shewed what principles are obtained from vegetable substances without the aid of fire; those which the heat of fire raises and carries over out of one close vessel into another; and, lastly, those that continue fixed after the vegetable hath been thoroughly charred, either in a

close vessel, or in the open air; nothing therefore remained, to finish the subject of vegetable principles, but to examine those which fire raises, in the form of vapours, smoke, and flame, from a vegetable matter burnt and consumed in the open air. Every body knows that soot consists only of these principles, collected in the shafts of chimneys, which serve as alembics for this sort of distillation in the open air. By analysing wood-soot, therefore, we shall discover the principles we are in quest of. The process we have given for that purpose is taken from Boerhaave's Chymistry, where we find it described with great exactness and precision.

As we are at present enquiring into the nature of vegetables only, it is evidently necessary that we chuse a soot produced by burning vegetables alone. Soot, though dry in appearance, contains nevertheless much humidity, as appears from this analysis; seeing there comes over at first a considerable quantity of phlegm, that doth not seem to be impregnated with any principle, except perhaps an extremely subtile, saline, and oily matter, that communicates to it a disagreeable smell, from which it cannot by any means be entirely freed

The white milky liquor, which follows this first phlegm, is still water, but much more impregnated with saline and oily parts than the former. By its smell, which is exceeding quick and pungent, we may judge it contains much volatile alkali; and accordingly, when re-distilled by itself, it yields a volatile spirit, and a volatile salt in a concrete form. With regard to its white colour, it is occasioned by the oily parts which are diffused and suspended, but not dissolved, in the water. When this second liquor is come off, there ascends a volatile alkali in a dry form, and a very thick black oil; because there is not moisture enough left to dissolve these principles, or rather to divide and disperse them.

The volatile alkali obtained from soot is, in a double

double respect, the product of the fire. In the first place, though it derives its origin wholly from wood, or other vegetables, which, when distilled in close vessels, yield no volatile alkali at all, yet it produces such a salt when analyzed in the present manner; whence it must be inferred that the principles of those vegetables are metamorphosed into a volatile alkali, by being burnt in the open air, and sublimed in the form of foot. Secondly, though foot when analyzed yields a great deal of this salt, yet this salt doth not formally pre-exist therein; for it doth not rise till after the phlegm, nor without a very considerable degree of heat: therefore foot contains only the materials necessary to form this salt; therefore the perfect combination of this salt requires that the force of fire be applied a second time; therefore it is, as was said, doubly the product of the fire.

The saline matter which we find sublimed into the neck of the retort, and which also forms the crust that covers the *cuput mortuum* of the foot, appears by all chymical trials to be an ammoniacal salt; that is, a neutral salt consisting of an acid and a volatile alkali. This ammoniacal salt rises only into the neck of the retort, and doth not come over into the receiver; because it is but semi-volatile. We shall treat more at large of the production of a volatile alkali, and of this ammoniacal salt, when we come to the analysis of animals, and the article of sal ammoniac.

The charred matter that remains in the retort after distillation, being burnt in the open air, is reduced to an exceeding fixed white earth. As this fixed matter was part of that very foot, which was sublimed to a great height while the vegetable was burning; this is a proof of what we advanced before, that the most fixed matters are capable of sublimation, when united with volatile substances;

especially when they are exposed at the same time to the combined action of air and of fire.



C H A P. VIII.

THE ANALYSES OF SOME PARTICULAR SUBSTANCES BELONGING TO THE VEGETABLE KINGDOM.

P R O C E S S I.

Analysis of the natural Balsams: instanced in Turpentine.

INTO a cucurbit put as much rain-water as will fill about a fourth part of its cavity, and pour into it the turpentine you intend to analyze. Cover the cucurbit with its head, and lute it on with slips of sized paper or wet bladder. Set your alembic in a sand heat; lute on a long-necked receiver; and give a gradual fire till the water in the cucurbit boil. There will come over into the receiver a good deal of phlegm, which, by little and little will become more and more acid; and at the same time there will rise a great quantity of an ætheral oil, extremely light, fluid, and as limpid and colourless as water.

When you observe that no more oil comes off, unlute your vessels; and in the receiver you will find an acidulated water, and the ætherial oil floating on it. These two liquors may be easily separated from each other, by means of a glass funnel.

In the cucurbit will be left some of the water you put in, together with the remainder of your turpentine; which, when cold, instead of being fluid as it was before distillation, will be solid, and
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of the consistence of a resin, and is then called *rosin*.

Put this residuum into a glass retort, and distill it in a reverberatory with a naked fire, gradually increased according to the general rule for all distillations. At first, with a degree of heat a little greater than that of boiling water, you will see two liquors come over into the recipient; one of which will be aqueous and acid, the other will be a transparent, limpid, yellowish oil, floating on the acid liquor.

Continue your distillation, increasing your fire from time to time, by slow degrees. These two liquors will continue to come off together: and the nearer the operation draws to its end, the more acid will the aqueous liquor become, and the thicker and deeper coloured will the oil grow. At last the oil will be very thick, and of a deep redish-yellow colour. When nothing more ascends, unlute your vessels: in the retort you will find only a very small quantity of a charred, light, friable substance.

OBSERVATIONS.

All natural balsams, as well as turpentine, are oily, aromatic matters, which flow in great quantities from the trees containing them, either spontaneously, or through incisions made on purpose. As these matters have a strong scent, it is not surprising that they should greatly abound with essential oils. They may even be considered as essential oils, that naturally, and of their own accord, separate from the vegetables in which they exist.

Indeed these natural balsams differ from the essential oils obtained out of plants by distillation, in this alone, that the former contain a greater proportion of acid; and, for that reason, are thicker than essential oils distilled with the heat of boiling

water. But it hath been shewn that these same distilled essential oils, though ever so fluid and light at first, gradually lose their tenuity as they grow old, and at last become considerably thick. On that occasion we observed that they are thus changed, because the lightest, most fluid, and least acid parts are little by little dissipated and evaporated; so that at last there remains only the thickest and heaviest part, which owes these qualities to the acid wherewith it is over-dosed.

Hence it follows that natural balsams, and essential oils grown thick with age, are exactly one and the same thing. Accordingly we see that fire and distillation produce the same effects on both. The rectification of an essential oil, thickened by keeping; is nothing but a decomposition thereof, by separating, with the heat of boiling water, all those parts that are light enough to rise with that degree of heat, from what is so loaded with acid as to remain fixed therein.

This operation is therefore precisely the same as our first distillation of balsams with the heat of boiling water, by which the essential oil contained in them is drawn off. The residues of these two operations are also the same: each of them is a thick oil, loaded with acid, that is wholly, or nearly, deprived of the principle of odour peculiar to the original vegetable, and requires a degree of heat greater than that of boiling water to decompose it, by separating part of the acid from the oil; which will be rendered still the more fluid, the more the thickening acid is separated from it by repeated distillations.

The newer natural balsams are, the thinner they are, and the more essential oil do they yield; and this essential oil, liker all others, grows thick in time and at last turns again to an actual balsam.

These balsams, by being long exposed to the heat of the sun, acquire such a consistence as to become

become solid. They then take another name and are called *resins*. Resins yield much less essential oil when distilled, than balsams do. Hence it follows that resins are to balsams, what balsams are to essential oils. All these effects are produced by the causes assigned above, and confirm the analogy we have established.

We have no other observations to make on this analysis of turpentine, except that when rosin is distilled in a retort with a naked fire, the operation must be carried on very slowly, and the fire duly governed: for the matter is apt to swell, and to rise in substance into the receiver, without being at all decomposed. In order to avoid this inconvenience, it is adviseable to make use of a long-bodied retort, such as is known by the name of the *English retort*.

If you stop the distillation of rosin about midway, or when the oil that comes over begins to grow thick, you may by changing the receiver keep the first oil apart: it is pretty fluid, and of a middle nature between the æthereal oil, obtained with the heat of boiling water, and the last thick oil, that doth not rise till towards the end of the distillation. This last thick oil is that which Mr. Homberg fired with concentrated oil of vitriol.

If we examine the matter contained in the retort, when the distillation is thus stopped short, it appears, when cold, in the form of a solid substance, almost perfectly diaphanous, of a deep redish-yellow colour, and friable: It is known by the name of *Colophony*.

This analysis of boiled turpentine, is a specimen of the analysis of almost all other resins; so that what hath been said on this occasion is, in a manner, general, and applicable to other decompositions of the same kind. We shall now proceed to examine some other oily matters, which exhibit peculiar

liar phenomena, and do not come under the general rules.

P R O C E S S II.

The Analysis of Resins : instanced in Benjamin. The Flowers and Oil of Benjamin.

INTO a pretty deep earthen pot, having a border or rim round its mouth, put the benjamin you intend to analyze. Cover the pot with a large conical cap of very thick white paper, and tye it on under the rim. Set your pot in a sand-bath, and warm it gently till the benjamin melt. Continue the heat in this degree for an hour and half. Then untie the paper cap and take it off, shaking it as little as possible. You will find all the inside of the cap covered with a great quantity of beautiful, white, shining flowers, in the form of little needles. Brush them off gently with a feather, put them into a bottle, and stop it close.

As soon as you take off the first cap, cover your pot immediately with a second like the former. In this manner go on till you perceive the flowers begin to grow yellowish; and then it is proper to desist.

The matter left in the pot will be blackish and friable when cold. Pulverize it; mix it with sand; and distill it in a glass retort with a graduated heat. There will come over a light oil, of a fragrant scent, but in very small quantity; a little of an acid liquor, and a great quantity of a red thick oil. There will be left in the retort a charred, spongy substance.

O B S E R V A T I O N S

All oily matters, that are naturally thick and in a concrete form, resemble each other in this, that
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they derive these qualities from an acid combined with them. But they nevertheless differ greatly from one another in many respects. The quality, the quantity, of the acid to which they owe their consistence, and the manner in which it is united with them, diversify them a thousand ways.

In the preceding process we advanced that natural balsams are distinguished from resins by their containing so much more oil, in proportion to their acid, as suffices to render them almost fluid. For this reason they yield an essential oil: whereas resins, on the contrary, are solid; all their oil being loaded and weighed down with a great quantity of acid, so that no essential oil can be drawn from them.

We observed at the same time, that, when all the essential oil contained in a natural balsam is drawn off, with the heat of boiling water, the residue takes a solid consistence, and resembles a resin. In fact almost all resins yield, by distillation, the same principles as that residue; that is, an oil of a middling nature between essential oils and thick oils, in point of lightness and fluidity; the whole being always accompanied with an acid diffused in phlegm.

In consequence hereof the analysis of benjamin, described in the process, appears to vary very much from that of other resins: for here we see a volatile matter in a concrete form; namely, the white flowers that rise first; which doth not usually occur in the analysis of resins. Yet, if we examine the matter, we shall be convinced that it is very analogous to one of the principles obtainable from all resins; that indeed it differs therefrom in some of its properties, particularly in its external form; but that it is in reality the very same.

In fact the flowers of benjamin are no other than an oily acid, nearly of the same nature with those obtained from all other vegetable substances; but which, instead of being liquid like them, appears
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in a dry concrete form, and in a mannner crystallized. It probably derives this property from its oil being combined with its acid, either in greater quantity, or in a more intimate manner, than in the rest, and so strongly united therewith as not to be separated from it by a subliming heat; or from hence, that the compound, of which it is a part, contains too little phlegm to dissolve it; or else, that it is hindered from dissolving therein by the oil with which it is combined. Perhaps all these causes may concur together in producing its concrete form.

The saline character of this substance appears chiefly from its being soluble in water: but the water must be very hot, and even boiling, before it will effect this solution; and when it cools, the salt shoots into fine needles at the bottom. This phenomenon directs us to a method of separating it from benjamin without sublimation.

For this purpose the resin must be boiled in water: the water will then dissolve the salt; and, as it cools, the salt will crystallize, and may be easily collected. But as the oil, with which the acid is combined, hinders the water from dissolving it so easily as it otherwise would, we cannot obtain quite so much of it, from the same quantity of benjamin, by decoction as by sublimation; the last portions thereof being united with a great quantity of oil, which defends them against the action of the water. This salt dissolves readily in spirit of wine, on account of the oil combined with it. A course of well connected experiments might give us a far greater insight into its natural properties than we can now boast of.

Benjamin yields a much smaller quantity of fluid oil by distillation than other resins do, because the greatest part of its oil is employed in the composition of its oily, volatile acid salt. The thick oil drawn from this resin, is thicker than that obtained

tained from any other resin, and even fixes like butter when cold ; nor can we get more than a very small quantity of acid in a distinct liquor. All these effects depend on what we mentioned above, in relation to its saline flowers ; to wit, the peculiar and intimate union between the acid and oily parts of this resin, so that the fire cannot so easily or so perfectly disjoin them, as it doth those of other resins.

Benjamin, when distilled, leaves in the retort much more of a charred coal, than is left by most other resinous matters. This may be owing to the considerable quantity of earthy matter which it contains, and which, perhaps, may also be one of the causes that contribute to give its salt a concrete form.

R E F L E C T I O N S.

ON THE NATURE AND PROPERTIES OF CAMPHOR.

WE do not propose to give an analysis of this singular body ; because hitherto there is no process known in chymistry by which it can be decomposed. We shall therefore content ourselves with reciting its principal properties, and making a few reflections on its nature.

Camphor is an oily concrete substance : a kind of resin, brought to us from the Island of Borneo, but chiefly from Japan. This substance resembles resins, in being inflammable, and burning much as they do ; it is not soluble in water, but dissolves entirely and perfectly in spirit of wine ; it is easily separated again from this menstruum, as all other oily matters are, by the addition of water ; it dissolves both in expressed and in distilled oils ; it hath a very strong aromatic smell. These are the chief properties which camphor possesses in common with resins :

refins : but in other respects it differs totally from them ; especially in the following particulars.

Camphor takes fire and flames with vastly more ease than any other resin. It is so very volatile, that it vanishes entirely in the air, without any other heat than that of the atmosphere. In distillation it rises entire, without any decomposition, or even the least alteration. It dissolves in concentrated mineral acids ; but with circumstances very different from those that attend other oily or resinous substances. The dissolution is accompanied with no effervescence, no sensible heat ; and consequently can produce no inflammation. Acids do not burn, blacken, or thicken it, as they do other oily matters ; on the contrary, it becomes fluid, and runs with them into a liquor that looks like oil.

Camphor doth not, like other oily matters, acquire a disposition to dissolve in water by the union it contracts with acids ; though its union with them seems to be more intimate than that of many oily matters with the same acids. On the contrary, if a combination of camphor and an acid be diluted with water, these two substances instantly separate from each other : the acid unites with the water, and the camphor, being entirely disengaged from it, swims on the surface of the liquor. Neither volatile alkalis, nor the most caustic fixed alkalis, can be brought into union with it ; for it always eludes their power.

Notwithstanding these wide differences between camphor and all other oily and resinous substances, the rule, that acids thicken oils, seems to be so universal, and so constantly observed by nature, that we cannot help thinking this substance, like all the rest, is an oil thickened by an acid. But what oil ? what acid ? and how are they united ? This is a subject for very curious enquiries.

With a yellow oil drawn from wine, and an acid vinous spirit, of which we shall say more under the article

of æther, Mr. Hellot made a kind of artificial camphor; a substance having the odour, flavour, and inflammability of camphor; an imperfect camphor. True camphor hath the levity, the volatility, and the inflammability of æther. Can it be a substance of the same nature with æther, a kind of solid æther, an æther in a concrete form?

P R O C E S S III.

The Analysis of Bitumens; instanced in Amber. The Volatile Salt and Oil of Amber.

INTO a glass retort put some small bits of amber, so as to fill but two thirds of the vessel. Set your retort in a furnace covered with its dome; fit on a large glass receiver; and, beginning with a very gentle heat, distill with degrees of fire. Some phlegm will first come off, which will gradually grow more acid, and be succeeded by a volatile salt, figured like fine needles, that will stick to the sides of the receiver,

Keep the fire up to this degree, in order to drive over all the salt. When you perceive that little or none rises, change the receiver, and increase your fire a little. A light, clear, limpid oil will ascend. As the distillation advances, this oil will grow higher coloured, less limpid, and thicker, till at last it will be opaque, black, and have the consistence of turpentine.

When you perceive that nothing more comes off, though the retort be red-hot let the fire go out. You will have in the retort a black, light, spongy coal. If you have taken care to shift the receiver, from time to time, during the distillation of your oil, you will have sundry separate portions thereof, each of which will have a different degree of tenu-

ity or thickness, according as it came over at the beginning, or towards the end of the distillation.

OBSERVATIONS.

The substance of which we have here given the analysis, together with all others of the same, that is, the bituminous kind, is by most chymists and naturalists classed with minerals: and so far they are right that we actually get these mixts, like other minerals, out of the bowels of the earth, and never procure them immediately from any vegetable or animal compound. Yet we have our reasons for proceeding otherwise, and for thinking that we could not, in this work, place them better, than immediately after those vegetable substances which we call resins.

Several motives determine us to act in this manner. The analysis of bitumens demonstrates, that, with regard to the principles of which they consist, they are totally different from every other kind of mineral; and that, on the contrary, they greatly resemble vegetable resins in almost every respect. In short, though they are not immediately procured from vegetables, there is the greatest reason for believing that they were originally of the vegetable kingdom, and that they are no other than resinous and oily parts of trees or plants, which by lying long in the earth, and there contracting an union with the mineral acids, have acquired the qualities that distinguish them from resins.

Mineralogists know very well that we find, every where in the earth, many vegetable substances, that have lain very long buried under it, and frequently at a considerable depth. It is not uncommon to find, under ground, vast beds of fossile trees, which seem to be the remains of immense forests: and bitumens, particularly amber, are often found among this subterraneous wood.

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These considerations, joined to proofs drawn from their analysis, make this opinion more than probable : nor are we singular in maintaining it, as it is adopted by many able modern chymists.

The analysis of amber, above described, may serve as a general specimen of the decomposition of other bitumens : with this single difference, that amber is the only one among them which yields the volatile salt aforesaid ; and this determined us to examine it preferably to any other. As for the rest, they all yield a phlegm, an acid liquor, and an oil ; which is thin at first, but grows thicker and thicker, as the distillation draws towards an end. It must be understood, however, that these acids and these oils may differ, according to the nature of the bitumens from which they are drawn ; just as the phlegm, the acid, and the oil, resulting from the decomposition of resins, differ in quantity and quality, according to the nature of the resins from which they are procured.

The principal differences observed between resins and bitumens are these : the latter are less soluble in spirit of wine ; have a peculiar scent, which cannot be accurately described, and of which the sense of smelling only can judge ; and their acid is stronger and more fixed. This last property is one of the motives which induce us to think that besides the vegetable acid, originally combined, with the resinous or oily matter now become a bitumen, a certain quantity of mineral acid hath, in a course of time, been superadded to constitute this mixt. We shall presently see that the fact is certainly so, in the case of amber at least.

Almost all authors, who mention the analysis of amber, have given different accounts of the volatility of its salt, and of the time of the distillation when it begins to rise. Some make it ascend immediately after the first acid phlegm. Others say that it doth not begin to appear till after the first

thin oil ; and others again affirm that it comes over with the last thick oil. Mr. Bourdelin, who hath examined this matter to the bottom, in a memoir on the analysis of amber given in to the academy, very judiciously remarks, that the different results, which those chymists met with in analyzing our mixt, arose wholly from the different manner wherein each conducted his fire during the operation.

It is certain that such a cause is capable of producing vast differences : for when fire is hastily applied, or made too violent, it not only confounds and tumultuously mingles the principles of the body to be analyzed, but it even frequently drives up the entire substance itself out of the retort into the receiver, without decomposing it at all. This is really so in the case of amber, and of almost all compound substances that are not extremely fixed.

It ought therefore to be observed, as a general and important rule in every analysis, to administer the fire exceeding slowly and cautiously, as one can never err on that side ; and to increase it only by such degrees as appear necessary for carrying on the distillation. By observing this method, an accurate analysis will be attained : by this means the salt of amber will rise before the oil ; whereas, if a degree of heat sufficient to raise the thin oil, or even the thick oil, be applied at first, the salt will accordingly come over with the one or the other of these oils.

Chymists remained a long time unacquainted with the nature of this salt of amber, and authors of the greatest name agreed as little on this point, as on that just mentioned. Some asserted it to be a volatile salt of the same kind with that which is obtained from animal substances ; that is, a volatile alkali : others, on the contrary, pretended that it was an acid of a singular nature.

It is very surprising that such authors should disagree on such a point; considering how easily it may be ascertained whether this salt may be really an acid or an alkali. Mr. Bourdelin justly decides the question in favour of those who affirm it to be an acid. In fact it hath all the properties of an acid: it hath the taste of one, forms neutral salts with alkalis, and differs from the most unquestionable acids in this alone, that, being combined with a portion of oil and a small quantity of earth, these give it a concrete form; which is not a solitary case in chymistry, as is evident from cream of tartar. With regard to its volatility, there is nothing in that repugnant to the properties of its constituent principles; seeing the acid and the oil predominant therein may easily be supposed to communicate their volatile nature to the small portion of earth with which they are combined.

Those chymists, who looked upon the salt of amber as a volatile alkali, either did not examine it thoroughly, but contented themselves with its first appearance, in which it resembles the volatile salt of animals, or else were led into the error by some particular circumstances. We know, for example, that animal as well as vegetable substances are dug out of the earth. The insects, sometimes found inclosed in lumps of amber, sufficiently prove this. Perhaps they made their experiments on such pieces of amber; or else, that which they used might be mixed with some animal substance not very perceptible. In such a case it would be no wonder if the volatile salt obtained should shew some tokens of an alkali: for the volatile alkali arising from the animal matter would only be mixed, not combined, with the salt of the amber; as the great quantity of oil, in which both these salts are entangled, would hinder them from dissolving each other, and forming such a neutral salt as would be produced in other circumstances.

The acid or alkaline nature of the salt of amber was not the only point that remained to be discussed on this occasion, Its acid quality being once clearly ascertained, the nature of this acid was next to be determined. This is the object chiefly aimed at in Mr. Bourdelin's memoirs, and his discovery thereof is unquestionably one of the finest, and at the same time one of the most difficult, that could be attempted with regard to this bitumen.

It appears plainly from several experiments, of which we have given an account in the course of this work, that the strongest mineral acids, by being combined with any oily matter, are so vastly altered, and so strangely disguised, that we not only are incapable of distinguishing what they are, but even can hardly avoid decomposing, and partly destroying them, by those very operations which seem the best adapted to separate them from the oil in which they are inviscated. Mr. Bourdelin had all these difficulties to surmount, and incessantly met with new obstacles in that troublesome fatty matter, which, like an impenetrable veil, concealed from his view the acid whose nature he wanted to discover. But at last, by dint of manifold experiments, he happily gained his end. Two parts of pure nitre, unadulterated with the least particle of sea-salt, and one part of amber, pulverized and mingled together, procured him, by deflagration, a salt partly neutral and partly alkaline ; which being lixiviated, and set to evaporate spontaneously, there formed at the bottom a residue of a mucilaginous, pappy, whitish matter, amongst which he could distinguish crystals, that were very transparent, regularly figured, of a cubical form, but rather oblong ; so that they represented little oblong squares most exactly formed, and about half a line thick

As these crystals perfectly resembled, in their figure, the neutral salt produced by a combination of the

the acid of sea-salt with the alkaline basis of nitre ; this was a proof to Mr. Bourdelin that the acid of amber is of the same kind, or rather exactly the same, with that of sea-salt. The nitre being alkalized by means of the phlogiston of the amber, the acid of the bitumen, finding this alkali a proper basis to fix in, unites with it, and by that means is enabled to resist the action of the fire, so as not to be carried off by it.

On the other hand, it is separated from the fat matter by which it was masked before ; for by the help of this fat matter the nitre is alkalized. The acid having by this means recovered all its properties, begins to discover them, as hath been said, by the figure it constantly gives to the crystals of the neutral salt which it helps to constitute.

Moreover, this neutral salt hath all the essential properties of sea-salt. It hath its taste ; it decrepitates in the same manner on live coals ; if oil of vitriol be poured on it, white vapours arise, which have the smell of spirit of salt, and are an actual spirit of salt. Lastly, it makes a white precipitate of mercury dissolved in spirit of nitre, and a *luna cornea* of silver dissolved in the same spirit ; which last proofs would alone be sufficient to establish Mr. Bourdelin's opinion, though we had no other.

It were to be wished that the experiments which Mr. Bourdelin hath made on amber were also tried on other bitumens. There is reason to think they would be found to contain either the marine or the vitriolic acid : for though they do not yield a volatile salt as amber doth, in distillation, yet the acids obtained from them are very strong, and appear, as we said before to have a mineral origin. Mr. Geoffroy observed that amber being pulverized, and infused in hot water, parts with its salt in the same manner as Benjamin does ; which gives room to suspect that amber is to bitumens what benjamin is to resins.

PROCESS IV.

The Analysis of Bee's-Wax, and such oily compounds as are analagous to it.

MELT the wax you intend to analyze, and mix with it as much fine sand as will make it into a stiff paste. Put this paste in little bits into a retort, and distill as usual, with a graduated fire, beginning with a very gentle heat. An acid phlegm will come over, and be followed by a liquor which at first, will look like an oil, but will soon congeal in the receiver, and have the appearance of a butter or grease. Continue the distillation, increasing the fire by insensible degrees, till nothing more will come off. Then separate the butter from the acid phlegm in the receiver, mix it with fresh sand, and distill it again just as you did the wax before. Some acid phlegm will still come off, and an oil will ascend, which will not fix in the receiver, though it be still thick. Continue the distillation, with a fire so governed that the drops may succeed each other at the distance of six or seven seconds of time. Do not increase it, till you perceive the drops fall more slowly; and then increase it no more than is necessary to make the drops follow each other as above directed. When the distillation is finished, you will find in the receiver the oil come wholly over, and a little acid phlegm. Separate the oil from this liquor; and, if you desire to have it more fluid, redistill it a third time in the same manner.

OBSERVATIONS.

Bee's-Wax, like all other oily matters in a concrete form, is an oil thickened by an acid. Its decomposition furnishes us with a very convincing proof

proof of this truth ; which, you see, is confirmed more and more, by every new analysis we make of such substances.

Wax doth not part with all its acid in the first distillation : and this is the reason that it doth not then become a fluid oil, but a butter, which hath only a degree of softness proportioned to the quantity of acid separated from it. The same thing holds with regard to its butter ; which losing by a second distillation, a great part of the remaining acid which caused its consistence, is by that means turned to an oil. Lastly, this oil, from being thick, becomes very fluid by a third distillation, and so follows the general rule of oils ; which always become the more fluid the oftener they are distilled or rectified.

What is here said concerning wax is applicable to resins also ; which it further resembles in its consistence, and its refusing to dissolve in water : yet it differs from them essentially in several respects ; and for this reason we thought proper to treat of it in particular. The properties in which it differs from resins are these :

First, it hath no aromatic scent, nor acrid taste, as resins have.

Secondly, it doth not yield a thin limpid oil in the first distillation, as they do.

Thirdly, its oil, or its butter, doth not grow sensibly thicker with age. Mr. Boerhaave kept some butter of bee's-wax for twenty years in a vessel that was not stoppt, but only covered with a bit of paper ; yet it did not grow hard. An essential oil, tho' kept much closer shut up, would in much less time have acquired the consistence of a balsam ; and a balsam, in that time, would have become a resin.

Fourthly, Bee's-wax is not soluble in spirit of wine ; whereas it is the very nature of resins to dissolve in that menstruum.

Fifthly,

P R O C E S S I V.

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Fifthly, I have observed that spirit of wine acts faintly on the butter of bee's-wax; dissolves that butter, when distilled to an oil; unites more readily with that oil when rectified by a third distillation; and dissolves it still the more readily the oftener it is distilled. Resins, on the contrary, are more soluble in spirit of wine than the thin oils drawn from them; and those oils acquire the property of resisting that menstruum more and more obstinately the oftener they are rectified.

By these differences we may judge whether it be proper to confound bee's-wax with resins, or whether it ought not rather to be considered as an oily compound of a singular species, which deserves to be ranked in a different class, or at last in some other division.

If we take the most cursory view of the properties of essential oils, and compare them with those of fat oils, we cannot avoid being struck with a resemblance between the properties of essential oils and those of resins, as well as with the apparent conformity between the properties of fat oils and those of bee's-wax: from all which we may conclude with good reason, in my opinion, that the oil of bee's-wax is not of the same nature with that of resins. The oil of resins hath all the properties of an essential oil, and is justly allowed to be an essential oil rendered thick and ponderous by an acid. The oil of bee's-wax, on the contrary, hath all the properties of fat oils; and there is great room to think that this substance is really no other than a fat oil hardened by an acid.

Bee's-wax is not the only oily compound that appears to have a fat oil for its basis. Certain shrubs in America yield, by decoction, a substance that hath all the properties of bee's-wax, differing therefrom only in its colour, which is green. The butter of Cacao is also a substance analogous to bee's-wax, and would be really wax, if it were but as hard;

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For it contains the same principles, but in different proportions : in short, it is to bee's-wax what balsams are to resins.

PROCESS V.

The Saccharine Juices of Plants analyzed : instanced in Honey.

PUT into a stone cucurbit the honey you intend to distill ; set it in a moderate sand-heat, and evaporate the greatest part of its humidity, till you perceive the phlegm begin to be acid. Then take out the matter remaining in the cucurbit, put it into a retort, leaving a full third thereof empty, and distill in a reverberatory with degrees offire. An acid, amber-coloured liquor will come over. As the operation advances this liquor will continually become deeper coloured and more acid, and at the same time a little black oil will ascend. When the distillation is over, you will find in the retort a pretty large charred mass, which being burnt in the open air, and lixiviated, affords a fixed alkali.

OBSERVATIONS.

If we consider nothing but the nature of the principles obtained from Honey, we may be induced to think that this substance is of the same kind with resins ; for we got from each a phlegm, an acid, an oil, and a coal. Yet there is a very great difference between these two sorts of compounds. Oily matters of the resinous kind are very inflammable and by no means soluble in water : Honey, on the contrary, is not inflammable in its natural state ; will not flame till it be half consumed, or turned almost to a coal, by the fire ; and mixes readily and perfectly with water. Now whence can this

this difference arise? Since it is not owing to the nature of the principles that constitute these mixts, it must necessarily be attributed to the proportions in which those principles are united. And indeed, if we attend to the quantities obtained from each by analyzing them severally, we shall find that, in this respect, there is a very great difference between them. Oily compounds of the nature of resins, which are not soluble in water, yield in distillation a little phlegm, a quantity of oil vastly exceeding that of their acid, and a very small matter of coal, which when burnt, scarce leaves any token of a fixed alkali. Honey, on the contrary, and all other juices of the same nature, give out, when analyzed, a great deal of phlegm, a quantity of acid much superiour to that of their oil, and a considerable mass of coal; from which, when burnt in the open air and lixiviated, a very perceptible alkali may be obtained.

If the quantity of the principles procured by these two analyzes be compared together, it will be easy to deduce from thence the causes of the different properties observed in the mixts that afforded them. In the large quantity of oil, of which resinous substances consist almost entirely, we see the cause of their being so inflammable, and so indissoluble in water. When such bodies are decomposed, there remains but little coal, and very little fixed alkali; because their oil carries off with it almost all their acid, leaving a scarce perceptible portion thereof fixed in the coal. Now we know that this acid is an essential requisite to the formation of an alkali. Honey on the contrary, and the analogous mixts, are so unapt to take fire, and mix so readily with water, only because there is very little oil in their composition, in comparison of the acid, which is their predominant principle. For the same reason they leave, when decomposed, a greater quantity of coal, which also yields much more

more fixed alkali than we find in the coals of resins. Perhaps these mixts may also contain a little more earth. The cause of this greater quantity of fixed alkali will be found in what we delivered above concerning the combination and production of that salt.

Sugar, manna, and the saccharine juices of fruits and plants, are of the same nature as honey, yield the same principles, and in the same proportions. All these substances must be considered as native soaps; because they consist of an oil rendered miscible with water, by means of a saline substance. They differ from the common artificial soaps in several respects; but chiefly in this, that their saline part is an acid, whereas that of common soap is an alkali. The natural soaps are not for that reason the less perfect: on the contrary, they dissolve in water without destroying its transparency, and without giving it a milky colour: which proves that acids are not less proper than alkalis, or rather that they are more proper additaments, for bringing oils into a saponaceous state.

But it must be owned that we are not yet able to imitate by art the acid soaps which are prepared and so perfectly combined by nature, and that the deterfive quality of these is not near so strong as that of the soaps which have an alkali for their saline principles.

Though honey, and the other vegetable substances analogous to it, contain much acid, yet they have no taste of sourness, nor any of the other properties of acids; but on the contrary their taste is soft and saccharine: the cause of this is that their acid is intimately mixed and perfectly combined with their oil, which entirely sheathes and blunts it.

PROCESS V.

Gummy Substances analyzed : instanced in Gum Arabic.

DISTILL gum arabic in a retort with degrees of fire. A limpid, scentless, and tasteless phlegm will first come over ; and then a russet coloured acid liquor, a little volatile alkali and an oil, which will first be thin and afterwards come thick. In the retort will be left a good deal of a charred substance, which being burnt and lixiviated will give a fixed alkali.

OBSERVATIONS.

Gums have at first sight some resemblance of resins ; which hath occasioned many resinous matters to be called gums, though very improperly: for they are two distinct sorts of substances, of natures absolutely different from each other. It hath been shown that resins have an aromatic odour ; that they are indissoluble in water, and soluble in spirit of wine ; that they are only an essential oil grown thick. Gums, on the contrary, have no odour, are soluble in water, indissoluble in spirit of wine, and, by being analyzed as in the process, are converted almost wholly into a phlegm and an acid. The small portion of oil contained in them is so thoroughly united with their acid, that it dissolves perfectly in water, and the solution is clear and limpid. In this respect gums resemble honey, and the other vegetable juices analogous to it. They are all fluid originally ; that is, when they begin to ooze out of their trees. At that time they perfectly resemble mucilages, or rather they are actual mucilages, which grow thick and hard in time by the evaporation

ration of a great part of their moisture : just as
resins are true oils, which, losing their most fluid
parts by evaporation, at last become solid, Infusi-
ons or slight decoctions of mucilaginous plants,
when evaporated to dryness, become actual gums.

Some trees abound both in oil and in mucilage :
these two substances often mix and flow from the
tree blended together. Thus they both grow dry
and hard together in one mass, which of course is
at the same time both gummy and resinous : and
accordingly such mixts are named gum-resins.

But it must be observed that these resinous and
gummy parts suffer no alteration by being thus mix-
ed ; but each preserves its properties, as if it were
alone. The reason is that they are not truly unit-
ed together : gums being indissoluble by oils or by
resins, the parts of each are only entangled a-
mong those of the other, by means of their visco-
sity. Hence if the gum-resin be put into water,
the water will dissolve only the gummy part,
without touching the resinous. On the con-
trary, if the same gum-resin be put into spirit of
wine, this menstruum will dissolve the resin, and
leave the gum. We shall treat more particularly of
this dissolution under the head of spirit of wine.

If a gum-resin, instead of being only infused in
water, be triturated with water, it will be thereby
wholly diffused through it : but the resinous part,
which is only divided by the triture, and not dissol-
ved in the water, gives the liquor a milky colour,
like that of an emulsion. It is indeed an actual e-
mulsion ; that which is made with kernels being,
like this, no other than a divided oil, dispersed in
small particles by triture, and suspended in the wa-
ter by means of a mucilage.



SECTION II.

Of Operations on Fermented Vegetable Substances.



CHAP. I.

OF THE PRODUCT OF SPIRITUOUS FERMENTATION.

PROCESS I.

To make Wine of Vegetable Substances that are susceptible of Spirituous Fermentation

LET a liquor susceptible of, and prepared for, spirituous fermentation be put into a cask. Set this cask in a temperately warm cellar, and cover the bung-hole with a bit of linen cloth only. In more or less time, according to the nature of the liquor to be fermented, and to the degree of heat in the air, the liquor will begin to swell, and be rarefied. There will arise an intestine motion, attended with a small hissing and effervescence, throwing up bubbles to the surface, and discharging vapours; while the gross, viscous, and thick parts, being driven up by the fermenting motion, and rendered lighter by little bubbles of air adhering to them, will rise to the top, and there form a kind of soft spongy crust, which will cover the liquor all over. The fermenting motion still continuing, this crust will, from time to time, be lifted up and cracked

cracked by vapours making their escape through it ; but those fissures will presently close again, till, the fermentation gradually going off, and at last entirely ceasing, the crust will fall in pieces to the bottom of the liquor, which will insensibly grow clear. Then stop the cask close with its bung. and set it in a cooler place.

OBSERVATIONS.

Matters that are susceptible of the spirituous fermentation are seldom so perfectly prepared for it by nature as they require to be. If we except the juices that flow naturally from certain trees, but often-er from incisions made on purpose in them, all other substances require some previous preparation.

Boerhaave, who hath handled this subject excellently well in his Chymistry, divides the substances that are fit for spirituous fermentation into five classes. In the first he places all the mealy seeds, the legumens, and the kernels of almost all fruits. The second class includes the juices of all fruits that do not tend to putrefaction. In the third class stand the juices of all the parts of plants which tend rather to acidity than to putrefaction ; and consequently those which yield much volatile alkali are to be excluded. The fourth class comprehends the juices or saps that spontaneously distill from several trees and plants, or flow from them when wounded, He forms his fifth and last class of the saponaceous, saccharine, and concrete or thick juices of vegetables. Resinous or purely gummy matters are excluded, as not being fermentable.

These five classes may be reduced to two ; one comprehending all the juices, and another all the mealy parts, of vegetables that are susceptible of fermentation. The juices want nothing to fit them for fermentation, but to be expressed out of the substances containing them, and to be diluted with a sufficient quantity of water. If they be very thick,

thick, the best way is to add so much water as shall render the mixed liquor just capable of bearing a new-laid egg. With respect to farinaceous substances, as they are almost all either oily or mucilaginous, they require a little more management. The method of brewing malt-liquors will furnish us with examples of such management. It is thus described by Mr. Boerhaave.

In warm weather the grain is put into large vats, and a considerable quantity of rain-water, or very clean river-water, is poured thereon, in which it lies till it be well soaked and swelled. This first operation is called the Steeping.

When the grain is by this means grown very plump, it is taken out of the steep, and laid on great heaps in an open place, yet not too much exposed in the wind. In a very little time those heaps grow hot, the grain begins to sprout, and shoot out little buds of leaves and roots. The art of managing this operation properly consists in seizing the exact point of time when the germination should be stopt: on this in a great measure depends the success of the business. For, if the grain be left too long in this hot bed, it may begin to rot, or else the leaves and roots, by growing too much, may consume most of the mealy substance, which, in this case, is the only subject of fermentation, and, if the germination be checked too soon, the advantage expected from it will be lost; that is the mucid matters will not be sufficiently attenuated.

As soon therefore as the germination is observed to have attained its proper stage, it must be stopt with all possible expedition. For this purpose the grain is carried into an open place exposed to the north wind, where it is spread on a boarded floor and dried; by which means it is hindered from sprouting any more. It is next made to run slowly down through a long tunnel made very hot, which at once dries it thoroughly to the very heart, and

in

in some measure scorches it; though very slightly. Grain thus prepared is called *Malt*.

By this germination, exsiccation, and slight torrefaction of the grain, the farinaceous substance is considerably attenuated, and its natural viscosity destroyed, which would otherwise hinder the meal, when boiled in water, from mixing with it and dissolving in it, as it must in some measure do to form a liquor fit for spirituous fermentation.

Mr. Boerhaave takes notice that if grain, which hath not been thus prepared, be chewed in the mouth, its meal makes a paste that is not easily attenuated, or entirely dissolved, by the spittle; whereas the meal of the same grain, after malting, mixes immediately and perfectly with the spittle; it hath moreover a sweet agreeable taste, which common grain hath not,

The grain being thus malted is ground: then hot water is poured thereon, in which it is left to infuse for three or four hours. In that time the water takes up all the attenuated flour of the malt; whereas it would not dissolve the farina of grain that had not undergone the above described preparations. The wort is then drawn off the grains, and boiled to a proper degree of inspissation; the decoction is suffered to cool, and afterwards put into casks to be fermented as the process directs.

As malt-liquor is apt to grow sour, and will not keep so long as wine, some bitter plants are usually boiled in the decoction, to make it keep the longer, and hinder it from turning sour so soon as it otherwise would. For this purpose such plants are chosen as have an agreeable bitter taste; and the preference is generally given to hops.

Besides these preparations, relating chiefly to malt-liquors, there are many other things to be observed relating to spirituous fermentation in general, and to all matters susceptible of that fermentation. For example; all grains and fruits designed for that fermentation must be perfectly ripe; for other-

otherwise they they will not ferment without difficulty, and will produce little or no inflammable spirit. Such matters as are too austere, too acrid, or astringent, are for the same reason unfit for spirituous fermentation ; as well as those which abound too much in oil.

In order to make the fermentation succeed perfectly, so as to produce the best wine that the fermented liquor is capable of affording, it is necessary to let it stand quiet without stirring it, lest the crust that forms on its surface should be broken to little fragments, and mix with the liquor. This crust is a kind of cover, which hinders the spirituous parts from exhaling as fast as they are formed. The free access of the air is another condition necessary to fermentation : and for this reason the vessel that contains the fermenting liquor must not be close stopped ; the bung-hole is only to be covered with a linen cloth, to hinder dirt and insects from falling into it. Nor must the bung-hole be too large, lest too much of the spirituous parts should escape and be lost.

Lastly, a just degree of warmth is one of the conditions most necessary for fermentation : for in very cold weather there is no fermentation at all ; and too much heat precipitates it in such a manner that the whole liquor becomes turbid, and many fermenting and fermented particles are dissipated.

If, notwithstanding the exactest observance of every particular requisite to excite a successful fermentation, the liquor cannot, without difficulty, be brought to effervesce, which scarce ever happens but to malt-liquor, it may be accelerated by mixing therewith some matter that is very susceptible of fermentation, or actually fermenting. Such matters are called *ferments*. The crust, or *yeast*, that forms on the surface of fermenting liquors is a most efficacious ferment, and on that account very much used.

It sometimes happens that there is occasion to
check

check the fermentation excited in the liquor, before it ceases of itself. To effect this, such means must be used as are directly opposite to those mentioned above for promoting fermentation. The end is obtained by mixing with the liquor a quantity of alkali, sufficient to absorb the acid contained therein : but this method is seldom made use of because it spoils the liquor : which after being thus treated, is incapable of any spirituous fermentation, but on the contrary will certainly putrefy.

Spirituous fermentation may also be stopped by mixing with the liquor a great quantity of some mineral acid. But this likewise alters its nature ; because these acids, being fixed, always remain confounded therewith, and never separate from it.

The best method yet found out for checking this fermentation, without injury to the fermenting liquor, is to impregnate it with the fumes of burning sulphur. These fumes are known to be acid, and it is that quality in them which suspends the fermentation. But at the same time this acid is extremely volatile : so that it separates spontaneously from the liquor, after some time, and leaves it in a condition to continue its fermentation.

For this reason when a wine is desired that shall be but half fermented, and shall partly retain the sweet taste it had in the state of *must*, (the proper name for the unfermented juice of the grape) it is put into casks in which sulphur hath been previously burnt, and the vapours thereof confined by stopping the bung-hole. These are called *matched wines*. If the same operation be performed on *must*, its fermentation will be absolutely prevented: it will retain all its saccharine taste, and is then called *stum*. As the sulphureous acid evaporates spontaneously, in no long space, it is necessary to fumigate matched wines or stums from time to time, when they are intended to be kept long without fermenting.

P R O.

P R O C E S S II.

To draw an Ardent Spirit from substances that have undergone the Spirituous Fermentation. The analysis of Wine.

FILL a large copper cucurbite half full of wine. Fit on its head and refrigeratory. Lute on a receiver with wet bladder, and distill with a gentle fire; yet so that the drops which fall from the nose of the alembic may succeed one another pretty quick, and form a sort of small continued stream. Go on thus till you perceive that the liquor which comes over ceases to be inflammable; and then desist. You will find in the receiver a clear liquor, somewhat inclining to an amber-colour, of a pleasant quick smell, and which being thrown into the fire instantly flames. The quantity thereof will be nearly a fourth part of the wine you put into the alembic; and this is what is called *brandy*; that is, the ardent spirit of wine loaded with much phlegm.

In order to rectify it, and reduce it to spirit of wine, put it into a long-necked matrafs, capable of holding double the quantity. Fit a head to the matrafs, and lute on a receiver: place your matrafs over a pot half-full of water; set this pot over a moderate fire; and with this vapour-bath distill your spirit, which will rise pure. Continue this degree of heat till nothing more will come over. You will find in the receiver a very clear colourless spirit of wine, of a quick but agreeable smell, which will catch fire at once by the bare contact of any flaming substance.

O B S E R V A T I O N S.

It hath been shewn that honey, and the vegetable juices analogous to it, such as *must*, and the juice

of all saccharine fruits and plants, yield by distillation no other principles than phlegm, an acid, and a small quantity of oil. The analysis of wine, and of all substances that have undergone the spirituous fermentation, shews us that this fermentation produces, and in some sense creates, in those mixts, a principle that did not exist in them before; I mean the ardent spirit, which is an inflammable liquor that is miscible with water. This liquor results from a closer combination of the acid and the oil, which are attenuated and united together by fermentation. To this oil, which is one of its constituent parts, its inflammability is owing, and the acid imparts to this oil the property of mixing with water, more perfectly and more intimately than when it makes a part of any other compound. Nay, there is, in the very composition of an ardent spirit, a certain quantity of water which is necessary to it, which is one of its essential parts, and without which it would not have the properties that characterise it. We shall presently have occasion to see, that, when spirit of wine is dephlegmated to a certain pitch, we cannot deprive it of any more of its aqueous parts, without decomposing a quantity of the spirit, proportioned to the quantity of water drawn from it.

Ardent spirits are more volatile than any of the principles of the mixt from which they are produced, and consequently more volatile than the phlegm, the acid, or the oil thereof, though they wholly consist of these. This cannot be attributed to any thing but a peculiar disposition of these principles, which are attenuated in a singular manner by the fermenting motion, and thereby rendered more susceptible of expansion and rarefaction.

The great volatility of the ardent spirit procures an easy method of separating it from the other principles of wine, and of dephlegmating it. For this purpose it need only be distilled with such a gentle heat as is just capable of raising the spirit, but

but too weak to produce the same effect on the other matters from which you desire to free it. For this reason the more slowly, and with the less heat, you distill your wine, the stronger and more spirituous will your brandy be. The same is to be said of the second distillation, by which brandy is changed into spirit of wine, or, in other words, dephlegmated. The spirit of wine thus drawn from it will be so much the better, the more exactly you observe the conditions here proposed.

If spirit of wine be treated in the same manner as brandy, that is, if it be rectified by distillation with the same precautions, it will be thereby dephlegmated as much as possible; and then it is called *alkohol*. By this rectification it is not only freed from its redundant phlegm, but also from some particles of acid and of oil, which, though much less volatile than itself, yet ascend with it in the first distillation: nor is it possible wholly to avoid this inconvenience.

Mr. Boerhaave proposes to dephlegmatic spirit of wine more easily, and more accurately, by distilling it from decrepitated sea-salt mixed, while very hot, with the spirit. This must certainly be a very good method; because decrepitated sea-salt powerfully attracts moisture, and consequently is very apt to imbibe and retain that which is in the ardent spirit: and spirit of wine doth not dissolve sea-salt; so that there is no reason to fear its being in the least contaminated therewith.

All fermented liquors do not yield near an equal quantity of ardent spirit; because they do not all, before fermentation, equally contain the principles necessary to produce an ardent spirit, in the most advantageous proportion or disposition.

There are several ways of proving whether or no spirit of wine be as highly rectified as it possibly can be, that is, whether or no it contain any more phlegm than is precisely necessary to constitute it

spirit

spirit of wine; and many chymists have judged that worthy of the title which burns away entirely, without leaving behind it the least token of humidity; or that which, being burnt on gun-powder, fires it at last.

But Mr. Boerhaave justly observes that neither of these is a sufficient proof because, though there should be a small quantity of unnecessary phlegm in spirit of wine, yet it may very well be evaporated and dissipated by the deflagration in either way. He therefore proposes another proof, which is much more to be depended on; that is, by mixing and shaking with the spirit of wine a small quantity of a very dry pulverized alkali. If this salt, when thus agitated, and even warmed, with spirit of wine, continue as dry as it was at first, it is a sign that the spirit is perfectly dephlegmated.

Mr. Boerhaave tried in this manner some spirit of wine that had fired gun-powder, and found it to contain so much phlegm that it moistened his salt very perceptibly: nay, one single drop of water, being mixed with a considerable quantity of spirit of wine, which before left the alkali perfectly dry, discovered itself in this way by the moisture it communicated to the very same salt.

Spirit of wine may also be contaminated with some heterogeneous substances; such as acid, alkaline, or oily matters. These are to be discovered by very easy experiments proper to each; for an acid or alkalious spirit of wine being mixed with a drop of violets will give it a red or a green colour, according to the nature of the saline matter contained in it; and, if it be combined with an oil, that will shew itself by the white milky colour which a drop of it will give to water.

Besides the ardent spirit, wine contains an acid united with a portion of earth and of oil, which give the acid a concrete form. This substance generally separates spontaneously from the wine, and

adheres, in the form of a strong crust, to the sides of the cask. It is called *tartar*, and is, properly speaking, the essential salt of wine. We shall exhibit the analysis of tartar, and treat of it more at length, in a chapter apart.

Wine-lees consist of the grossest parts of the fermented liquor; which being incapable of remaining dissolved, sink to the bottom, and form a sediment, which contains also some tartar and a little ardent spirit.

The residue left in the cucurbite, after the spirit is drawn off, is a sort of extract of wine. This liquor hath an exceeding rough, or rather acid taste. When distilled it yields an acid phlegm, which comes more and more acid as the distillation advances, and a foetid empyreumatic oil. From the *caput mortuum*, when burnt, a considerably quantity of a fixed alkali may be extracted.

From all this it follows that wine consists of an ardent spirit, and a tartarous acid, diffused through a great quantity of water, together with some oily and earthy parts,

Malt liquor contains much less tartar than wine; but, instead thereof, it is impregnated with a mucilaginous matter, which becomes very perceptible when any body is smeared with it and dried; for then it makes a kind of varnish. This mucilaginous matter, which is not sufficiently attenuated, especially when the malt-liquor is new, makes it very apt to swell up and rise over the helm with rapidity, in the distillation of an ardent spirit from it: for which reason it is necessary to proceed more cautiously, and more slowly, in distilling a spirit from this liquor than from wine.

P R O C E S S III.

To dephlegmate Spirit of Wine by the means of Fixed Alkalis. Spirit of Wine analyzed.

INTO a glass cucurbite pour the spirit of wine you intend to dephlegmate, and add to it about a third part of its weight of fixed alkali, newly calcined, perfectly dry, heated, and pulverized. Shake the vessel, that the two matters may be mixed and blended together. The salt will gradually grow moist, and, if the spirit of wine be very aqueous, melt into a liquor, that will always ly at the bottom of the vessel, without uniting with the spirit of wine which will swim at top.

When you perceive that the alkali attracts no new moisture, and that no more of it melts, decant your spirit of wine from the liquor beneath it, and add to your spirit fresh salt thoroughly dried as before. This salt also will imbibe a little moisture; but it will not grow liquid, because the alkali, with which it was mixed before, hath left too little phlegm to melt this. Decant it from this salt as at first, and continue to mix and shake it in the same manner with fresh salt, till you observe that the salt remains as dry after as it was before mixing it with the spirit of wine. Then distill your spirit in a small alembic with a gentle heat, and you will have it as much dephlegmated as it can be.

O B S E R V A T I O N S.

Next to the mineral acids, fixed alkalis perfectly calcined are the substances which have the greatest affinity with water, and therefore it is no wonder they are so very fit to dephlegmate spirit

of wine, and to free it from all its redundant humidity. Indeed spirit of wine cannot be perfectly dephlegmated without their assistance: for when distillation alone is made use of for that purpose, it is impossible to prevent some phlegm from rising with the spirit of wine whatever precautions we take to avoid it. Hence it comes to pass that spirit of wine, though ever so highly rectified by distillation, always imparts a little moisture to an alkali, when mixed with it in order to prove its goodness.

But, while the alkali attracts the super-abundant phlegm of the spirit of wine, it produces in that liquor, and undergoes itself, remarkable changes.

Spirit of wine, when so highly dephlegmated by an alkali that, being kept in digestion therewith it leaves the salt perfectly dry, hath a red colour, an odour somewhat different from that which is peculiar to it when perfectly pure, a taste in which that of the fixed alkali may be distinguished: and it makes a slight effervescence with acids: which manifestly proves that it is united with a portion of the alkali employed to rectify it.

Mr. Boerhaave thinks, with great probability, that this portion of the alkali unites with the spirit of wine, much in the same manner as with oils, viz. that it forms with the spirit a kind of liquid soap. He observes that this alkalized spirit cleans the fingers; and that things wetted with it do not dry so speedily as those wetted with pure spirit of wine. This alkalized spirit is also called *tincture of salt of tartar*.

In making this alkaline tincture, great care is to be taken that the spirit of wine you use be as highly rectified as possible: for, as long as it communicates any phlegm to the alkali, it doth not acquire from the salt mixed with it either the red-colour, or the other properties which shew it to have dissolved part thereof. It is also a rule to throw

throw the alkali exceeding hot into the spirit of wine, which being heated before hand boils on the addition of the hot salt. In order to render the tincture still stronger, they are left to digest together for some time; after which, if part of the spirit of wine be drawn off by distillation, the remainder will have a redder colour and a more acrid taste.

The spirit drawn off by distillation is clear, colourless, and doth not give the same tokens of an alkaline quality as the tincture; and for that reason, as the design of the present process is only to dephlegmate and rectify spirit of wine by means of a fixed alkali, we have directed it to be distilled as soon as all its phlegm is absorbed by the salt.

However, spirit of wine rectified in this manner must not be considered as absolutely pure; for a small degree of an alkaline quality is still perceptible in it: but that doth not hinder its being employed with success in several chymical operations, where the property chiefly required in spirit of wine is that it be perfectly dephlegmated.

In order to free spirit of wine from the small portion of alkali remaining in it after distillation, Mr. Boerhaave proposes to mix with it a few drops of the vitriolic acid, before the last distillation. But there is great reason to apprehend an opposite inconvenience from this practice: that is, instead of an alkaline character, we may give the spirit an acid taint. Indeed this cannot be avoided, but by mixing with the spirit of wine exactly as much acid, as suffices to saturate the alkali contained in it, and no more; which is a point very difficult to hit.

Van Helmont tells us that having distilled spirit of wine from salt of tartar perfectly calcined, half of it came over pure water; and Mr. Boerhaave, to whom this appeared very surprising, resolved to repeat Van Helmont's experiment, in order to sa-

tisfy himself of the truth, and see with his own eyes what would be the result. With this view he made a tincture of salt of tartar in the manner above described, as strong and as fully impregnated as he possibly could. He set it in digestion with the alkali for several months, and afterwards let it stand four years without touching it. He then poured the whole into a cucurbite, and drew off the spirit of wine from the salt by distillation. The spirit of wine, which was before very red, became clear on being distilled, having left its colour in the salt which remained at the bottom of the cucurbite. This spirit he returned upon the salt, and distilled as before. He observed, that, in this second distillation, the spirit of wine rose with a little more difficulty, and that the remaining salt was of a more saturated colour, and become of a dark red. In this manner, he cohobated and distilled his spirit twenty times, with the same salt. He then found that the spirit of wine had acquired a caustic, fiery taste, and that the saline mass in the bottom of the cucurbite was grown black. This saline residue he distilled with a stronger fire, and obtained from it a liquor, which was water, and not spirit of wine.

Though Mr. Boerhaave seems, by this tedious labour, to have made Van Helmont's experiment succeed, at least in part, yet that famous and accurate philosopher did not flatter himself with the notion of having solved the problem. He first observes that he was far from getting the quantity of water which Van Helmont says he obtained, viz. half the weight of the spirit of wine. Secondly, he could scarce think that the quantity he did obtain actually came from the spirit of wine. The thing appeared to him so singular, and so hard to be accounted for, that he inclined to believe the water was quite extraneous both to his spirit of wine and to his salt, and that it came from the air, which

which could not but be admitted in the frequent cohobations of the spirit of wine with the alkali.

When Mr. Boerhaave undertook this long laborious course of operations, he had it also in his view to try whether he could not, by the same means, solve another problem famed among the chymists, namely, the volatilization of the salt of tartar. He acquaints us that in this also he failed; which may easily be believed: but, in my opinion, he was more successful, with regard to the first point, than he himself imagined, for I think the water he obtained came immediately from the spirit of wine. We shall easily be convinced of this, if we carefully consider all the circumstances attending his experiments.

It hath been shewn that spirit of wine consists of an oil, of an acid, and of water, with which the oil is intimately mixed by means of the acid; that spirit of wine, which is not perfectly dephlegmated, may be deprived of a pretty considerable quantity of water, which is superfluous and unnecessary to its composition; and that it suffers no change thereby, except that it becomes lighter, stronger, more inflammable, in short, more spirit of wine: but that, when it is once freed of this super-abundant phlegm, it would be in vain to attempt separating a greater quantity of water from it. All the water then left in it is essential to its composition, and necessary to give it its properties; for without that, it would not be spirit of wine, but only an oil loaded with an acid.

This being laid down, the water which cannot be separated from spirit of wine while it continues spirit of wine, must become sensible when it is decomposed. And this actually comes to pass: for if you rob the spirit of wine of one of its principles, its oil, for instance, and for that purpose burn it under a glass bell, as you do sulphur, you will by this means collect a great quantity of water, even though

though you make use of the most highly rectified spirit of wine; which proves that this water was one of the essential parts that constituted the spirit.

If, instead of depriving this mixt of its oily principle, you separate from it one of its other principles, such as its acid, it is plain that it will in like manner be decomposed, and that then the oil and the water, which were combined together only by means of that acid, will separate from one another, and appear each in its natural form. Now this is exactly the case in Van Helmont's experiment, as repeated by Boerhaave. The fixed alkali, on which the spirit of wine is cohobated, hath a greater affinity with the acid of this mixt than with its phlegm or its oil. It therefore unites with part of that acid; by which means a proportional quantity of its oil and water must needs separate from each other, and of course a portion of the spirit of wine will be decomposed. Accordingly Boerhaave observed, that, in dephlegmating spirit of wine by a fixed alkali, a portion of oil is always separated from it, and that the alkali employed in this operation is impregnated with an acid, so that, when it hath been several times used for this purpose, it is almost changed into a neutral salt, and hath acquired the properties of the foliated salt of tartar. That on which spirit of wine hath been cohobated a great number of times must consequently be impregnated with a great quantity of acid; and, as the acid carries with it a great deal of water, it is not surprising that when the alkali, thus impregnated with acid and phlegm, is exposed to a strong fire, the phlegm should be separated from it; seeing the union between them is but weak.

Thus it appears that the water obtained by Mr. Boerhaave, in his experiment, came immediately from the spirit of wine, agreeably to Van Helmont's notion; whose most intelligent followers have clearly explained his sentiments on this subject, telling us,

as their author's positive assertion, that, "in his experiment, the purest spirit of wine deposits one of its principles in the salt of tartar; that another of them is turned into water, and so separated from that spirit, and from the principle attracted by the salt of tartar; that consequently spirit of wine certainly consists of these two principles, which may be separated from each other; and that the principle which unites with the alkali of the tartar changes that salt into a medicament, or balsam, of admirable virtue in curing wounds, known by the title of the *samech* of *Paracelsus*."

It may here be asked why Boerhaave obtained but a small quantity of water in his experiment, seeing Van Helmont pretends that it ought to be equal to half the weight of the spirit of wine. The most natural answer to this question is, that, as Van Helmont did not publish all the circumstances of his experiment, there is reason to think Boerhaave did not go about it in the same manner as Van Helmont did.

In my opinion he would have succeeded perfectly, and have obtained from his spirit of wine the whole quantity of water he desired, if, instead of cohobating it always on the same alkali, he had taken fresh alkali every time; had drawn a tincture from it; had distilled his spirit of wine from this salt; and, after collecting all the parcels of alkali remaining after those distillations, he had exposed them to a strong fire, in order to separate all the moisture contained in them. Perhaps also such a great number of cohobations and distillations would not have been necessary to decompose the spirit of wine totally by this method; especially if he had employed a greater quantity of alkali in each operation. For it is evident that a fixed alkali, by being impregnated with a certain quantity of the acid and water of the spirit of wine, loses thereby a great deal

deal of its strength and activity, and at last becomes incapable of absorbing any more; so that, when it is entirely saturated, it is no more able to act upon spirit of wine, so as to decompose it, than so much vitriolated tartar, or common sand. Hence you see that there are still many beautiful experiments to be made on this subject, and that we may hope by a regular course of them to obtain a perfect solution of Van Helmont's problem.

In the following processes we shall treat of another method of decomposing spirit of wine, which consists in depriving it of its essential water, or aqueous principle, by the means of highly concentrated acids.



CHAP. II.

SPIRIT OF WINE COMBINED WITH DIFFERENT SUBSTANCES.

PROCESS III.

To combine Spirit of Wine with the Vitriolic Acid. This combination decomposed. Rabel's Water. Æther. Sweet Oil of Vitriol. Hoffman's Anodyne Mineral Liquor.

INTO an English glass retort put two pounds of spirit of wine perfectly dephlegmated, and pour on it at once two pounds of highly concentrated oil of vitriol: shake the retort gently several times in order to mix the two liquors. This will produce an ebullition, and considerable heat; vapours will ascend, with a pretty loud hissing noise, which will diffuse a very aromatic smell, and the mixture will be of a deeper or lighter red colour, according

the spirit of wine was more or less oily. Set the retort on a sand bath made nearly as hot as the liquor; lute on a tubulated ballon, and distill the mixture with a fire strong enough to keep the liquor always boiling: a very aromatic spirit of wine will first come over into the ballon, after which the æther will rise. When about five or six ounces of it are come off, you will see in the upper concavity of the retort a vast number of little points in a veined form, which will appear fixed, and which are nevertheless so many little drops of æther, rolling over one another, and trickling down into the receiver. These little points continue to appear and succeed each other to the end of the operation. Keep up the same degree of fire, till upon opening the little hole in the ballon you perceive that the vapours, which instantly fill the receiver, have the suffocating smell of volatile spirit of sulphur*.

Then unlute the ballon, pour the liquor it contains into a crystal bottle, and stop it close: there will be about eighteen ounces of it. Lute on your receiver again, and continue the distillation with a greater degree of fire. There will come over an aqueous, acid liquor, smelling strong of a sulphureous spirit, which is not inflammable. It will be accompanied with undulating vapours; which being condensed will form an oil, most commonly yellow, one part of which will float on the surface of the liquor, and another will sink to the bottom.

* These white vapours do not appear when the vessels are perfectly close. Mr. Hellot, to whom we owe the remark, having performed this operation in a crystal retort procured from London, the neck of which had been rubbed with emery in the mouth of its receiver, so that these two vessels fitted each other exactly, saw the æthereal liquor distill pretty fast, but without white vapours. He then loosened the receiver, by turning it a little upon the neck of the retort, so that the external air might get in; whereupon the white vapours appeared immediately. When the receiver was close fitted on again, the vapours disappeared. He repeated the same thing five times from half hour to half hour, and these vapours as often appeared and disappeared.

Towards the end of the distillation of this acid liquor, and of the yellow oil of which it is the vehicle, that part of the mixture, which is left in the retort and grown black, will begin to rise in froth. Then suppress your fire at once: stop the distillation, and change your receiver once more. When the vessels are grown pretty cool, finish your distillation with a lamp-heat, kept up for twelve or fifteen days, which in all that time will raise but a very little sulphureous spirit. Then break your retort, in which you will find a black, solid mass, like a bitumen. It will have an acid taste, arising from a remainder of the acid imperfectly combined with oil.

This artificial bitumen may be freed from its redundant acid, by washing it in several waters. Then put into a glass retort, and distill it with a strong reverberated fire. You will obtain a redish oil that will swim on water, much like the oil obtained by distilling the natural bitumens. This oil also will be accompanied with an aqueous acid liquor. In the retort will be left a charred matter, which, being put into an ignited crucible in the fire, burns for some time, and, when well calcined, leaves a white earth.

The liquors that rise first in this distillation, and which we directed to be kept by themselves, are a mixture consisting 1. of a highly dephlegmated spirit of wine of a most fragrant smell; 2. of æther, which the spirit of wine wherewith it is united renders miscible with water; 3. of a portion of oil, which commonly rises with the æther, towards the end of the operation; 4. and sometimes of a little sulphureous acid, if the receiver be not changed soon enough.

In order to separate the æther from these other substances, put the whole into an English retort with a little oil of tartar *per deliquium* to absorb the sulphureous acid, and distill very slowly in a sand-bath

the caustic alkali is preferable.

bath heated by a lamp, till near half the liquor be come over. Then cease distilling; put the liquor in the receiver into a phial with some water, and shake it; you will see it rise with rapidity to the upper part of the phial, and float on the surface of the water: this is the æther.

OBSERVATIONS.

This operation is only a decomposition of spirit of wine by means of oil of vitriol. In the preceding progress we saw that this spirit, which consists of three essential principles, viz an oil, an acid, and water, cannot be deprived of one of them without being at the same time decomposed; the two others that remain having by such separation lost the bond of intimate union and connection that was between them. We saw also that spirit of wine, when mixed and digested with a very caustic fixed alkali, and several times distilled from it, deposits its acid in that salt: and hence it comes that the oil and the water, being deprived of the principle which was the bond of their union, separate from each other, and appear in their natural forms.

In the present experiment the vitriolic acid decomposes the spirit of wine in a different manner. We know that this acid acts powerfully on oils; and that, when it is highly concentrated, as the operation requires it should be, it seizes and attracts with surprising force the moisture of all bodies that touch it. So that, when it is mixed with spirit of wine, it acts at the same time both on the aqueous and on the oily principle of that mixt. The rapidity and activity, wherewith it rushes into union with these substances, produce the heat, the ebullition, and the hissing noise, which we observe during the first moments after their mixture.

The red colour, which the two liquors confounded together acquire after some time, is owing to the combination of the acid with the oily part: for it is known that oils, as colourless as spirit of wine, such as the essential oil of turpentine, become of a brownish red when dissolved by a concentrated acid: and Kunckel observed, that, the more oil there is in spirit of wine mixed with oil of vitriol, the deeper is the red colour it acquires on being so mixed. He even gives this experiment as the certain means of discovering whether spirit of wine be more or less oily; and he adds, that spirit of wine, which hath lost part of its oil by being rectified with lime, acquires less redness than any other by being mixed with oil of vitriol.

When the mixture hath acquired this colour, and before it undergoes distillation, it appears like a homogeneous liquor. There is as yet no decomposition; or at least none that is perceptible; and the vitriolic acid is united at the same time with the oil, the acid, and the water of the spirit of wine; that is, with the whole spirit of wine in substance. This mixture, when made with three parts of spirit of wine to one of oil of vitriol, is an astringent remedy much used in hemorrhages, and known by the name of *Rabel's water*.

The actual decomposition of the Spirit of Wine is effected by the distillation. The first liquor, or the first portion of the liquor that rises before the rest, hath the smell and all the properties of spirit of wine. It is indeed part of the spirit of wine employed as an ingredient in the mixture; but, being abstracted from a highly concentrated oil of vitriol, which, of all known substances, attracts moisture with the greatest power, it is perfectly freed of all its unnecessary phlegm, and retains no more than what is a constituent part thereof, as one of its principles, without which it would not be spirit of wine.

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The liquor that succeeds this first spirit of wine is of a different nature. It may be considered as an æther: for, though it be not a pure æther, it contains the whole of it: from this liquor only can it be obtained; it is no other than an æther mixed with some of the spirit of wine that comes over first, and a little of the acid liquor which comes afterward. Now the production of æther is the effect of a beginning decomposition of the spirit of wine: it is spirit of wine degenerated, half-decomposed; spirit of wine too highly dephlegmated; that is, spirit of wine which hath lost a part of its essential phlegm, of that phlegm which as a necessary principle made it spirit of wine: it is a liquor still composed of oily parts mixed with aqueous parts, and on that account must retain a resemblance of spirit of wine; but such that its oily parts, not being dissolved and diffused among a sufficient number of aqueous particles, are brought nearer to each other than they should be to constitute perfect spirit of wine; on which account it is not now miscible with water, but is as much nearer to the nature of oil, as it is removed from the nature of spirit of wine: it is a liquor, in short, which, being neither spirit of wine nor pure oil, yet possesses some properties in common with both, and is consequently to be ranked in the middle between them.

This explanation of the nature of æther, which I imagine was never before given by any other, is the same that we proposed in our elements of the Theory of Chymistry, which may be consulted on this occasion.

An objection against this opinion may, perhaps, be drawn from an experiment well known in Chymistry. It may be said, that, if æther were nothing but depraved spirit of wine, which ceases to be miscible with water, because the loss it hath sustained of a portion of the water necessary to its constitution hath disordered the proportion which ought to

subſiſt between its aqueous and oily parts, from which proportion it derives that property, it would be very eaſy to change ſpirit of wine into æther by a method quite contrary to the uſual one; viz. by mixing ſpirit of wine with a ſufficient quantity of ſuperfluous oil: for it ſeems to be a matter of indifference whether the proportion, between the aqueous and the oily parts of ſpirit of wine, be changed by leſſening the quantity of the former, as in the common operation for æther, or by increaſing the quantity of the latter, as is here propoſed; and we can, by the laſt method, put theſe two principles together in what proportion we pleaſe. Now it is certain that, whatever quantity of oil be diſſolved in ſpirit of wine, it will ſtill remain miſcible with water; and that, if ſpirit of wine thus replete with oil be mixed with water, it will unite therewith as uſual, and quit the oil which it had diſſolved.

This objection, though ſeemingly a very ſpecious one, will be removed with the utmoſt eaſe, if we reflect but ever ſo little on ſome of the principles already laid down. We ſaid, and we gave ſome inſtances of it, that certain ſubſtances may be united together in ſundry different manners; ſo that from theſe combinations, though made in the ſame proportions, there ſhall reſult compounds of very diſſimilar properties. The combination we are now conſidering is another evidence of this truth. It is allowed that the proportion between the oily and the aqueous parts may be exactly the ſame in æther and in ſpirit of wine replete with oil; but it muſt alſo be owned that the manner in which the oil is combined in theſe two caſes is very different.

That oil, which at firſt is a conſtituting part of the ſpirit of wine, and afterwards becomes a part of the æther, is united with the other principles of thoſe mixts, that is, with their acid and their water, by the means of fermentation, whereby it is much more attenuated, and much more cloſely combined,

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than that with which spirit of wine is impregnated by dissolution only. And accordingly this adventitious oil is so slightly connected with spirit of wine, that it is easily separable from it by barely distilling it, or even mixing it with water: whereas that which makes a part of spirit of wine, as one of its constituent principles, is united therewith in such a manner as not to be separable from it by either of these methods, nor indeed without employing the most vigorous and powerful agents for that purpose. So that the chief differences between æther and oily spirit of wine must be ascribed to the different manner in which the oil is combined in these two mixts: and, if a sufficient quantity of superfluous oil could be united with spirit of wine, in such a manner that, without being soapy, it should not be separable therefrom by the affusion of water, I make no doubt but such a spirit of wine would be perfectly like æther; so far as not to be miscible with water.

But let us return to our distillation, and trace the decomposition of spirit of wine by the vitriolic acid. We have shewn that the acid begins with attracting part of the water which constitutes the spirit of wine, by which means it changes the nature of this compound, destroys its miscibility with water, and brings it as much nearer to the nature of an oil, as it thereby removes it from the nature of spirit of wine.

According to the theory laid down it is evident, that, if the acid continue to act in the same manner on spirit of wine thus depraved and become æther; that it, if it continue to draw from it the small remaining quantity of the aqueous principle, to which it owes the properties it still retains in common with spirit of wine, this must produce a total decomposition thereof; so that the oily parts, being no longer dissolved and divided by the aqueous parts, will be collected together, unite, and appear

under their natural form, with all their properties. Now this is exactly the case. The vitriolic acid rises in the distillation after the æther; but considerably changed, because it is loaded with the scattered remains of the decomposed spirit of wine. It is in a manner suffocated by the water it hath attracted from the spirit; which is the reason why it appears in the form of a very aqueous acid liquor. It carries up along with it the oil which it hath separated from that water: this is the oil we took notice of in the process; and it is consequently that very oily principle which actually constituted the spirit of wine. Lastly, by acting on this oil also, it takes up a portion of phlogiston, which renders it sulphureous.

What remains in the retort is also a portion of the oil, that was contained in the spirit of wine, now combined with some of the acid; which is the reason why it is black and thick. It is a compound much resembling a bitumen, and when analyzed yields the same principles we obtain from native bitumens, or from an essential oil thickened and half burnt by its combination with concentrated oil of vitriol.

As to the acid of the spirit of wine, some of it remains combined with the æther: but there is great reason to think, that, when the vitriolic acid robs the spirit of wine of its aqueous part, it takes up at the same time most of its acid, which being itself very aqueous, may be considered as pure water with respect to the concentrated oil of vitriol, by which it is attracted, and with which it is confounded.

The properties which characterize æther agree perfectly well with what we have said of its nature, and of the manner in which it is produced. It is one of the lightest liquors we know; it evaporates so suddenly, that, if a little of it be dropt on the palm of your hand, you will scarce perceive the part

part it touches to be wet by it; it is more volatile than spirit of wine; which is not at all surprising, seeing it differs therefrom only by containing less water, which is the heaviest principle in spirit of wine.

Æther is more inflammable than spirit of wine; for, if any flame be brought but near it, it immediately catches fire. The reason of this is, that the oily parts of which it consists are not only as much attenuated, and as subtile, of those of spirit of wine, but also in a greater proportion with regard to its aqueous parts. To the same cause must be attributed the facility with which it dissolves any oily matters whatever.

Æther burns without smoke, as spirit of wine does, and without leaving any coal or earthy matter behind; because the inflammable or oily parts contained in it are, in this respect, disposed like those of spirit of wine.

The properties of not being miscible with water, and of taking up gold dissolved in *aqua regis*, it possesses in common with essential oils; but the latter property it possesses in a much more sensible degree than any oil: for essential oils sustain the gold they thus take up but a little while; whereas the æther never lets it fall. It seems the ancient chymists were unacquainted with the æther; or at least, if they did know it, they made a mystery of it, according to custom, and spoke of it only in enigmatical terms. Amongst the moderns Frobenius, a German chymist, seems to have been the first who brought it to perfection. Godfrey Hankwitz, also a German, but settled in England, made mention of it much about the same time in the philosophical transactions. According to the latter, Mr Boyle and Sir Isaac Newton both knew the preparation of æther, for which they had each a different process. But none of these chymists ever published an exact and circumstantial account of

of a method by which this liquor might be prepared : so that Mess. Duhamel, Grosse, and Hellot, who have since made several experiments for that purpose, and have discovered, and communicated to the public, easy and certain methods of procuring æther, had no assistance in their labours but from their own skill and sagacity ; which gives them a just title to the honour of the invention. Mr. Beaumé also, a very ingenious artist in Paris, who hath bestowed a great deal of pains on this subject, lately communicated to the Academy a memoir, which, among several very important observations, contains the commodious and expeditious process above inserted. As there are many experiments in Mr. Hellot's memoir, agreeing perfectly well with what hath been said concerning the decomposition of spirit of wine by the vitriolic acid, we think it will be proper to take notice of them here, and to examine them briefly at least.

The quantity, the colour, and the weight of the oil, which rises in the distillation at the same time with the aqueous acid liquor, are various, according to the different proportions of spirit of wine and oil of vitriol that are mixed together. Mr. Hellot observed that by increasing the quantity of the vitriolic acid he obtained more of this oil, and less of the ardent spirit containing the æther. The reason is this : the more oil of vitriol you put in the mixture, the more spirit of wine must be totally decomposed, and consequently the more of this oil will be obtained ; which, as we have shewn, is one of the principles resulting from the decomposition of spirit of wine.

“ This oil is also lighter or heavier, in proportion to the quantity of oil of vitriol poured on the spirit of wine. That which arises from mixing six, five, four, or even three parts of spirit of wine with one part of concentrated oil of vitriol, always floats on the water, and continues

“ white

white. That which ascends from two parts of spirit of wine is yellow, and most commonly sinks; and, lastly, that which is produced from equal parts of these two liquors is greenish, and constantly falls to the bottom."

Mr. Hellot remarks, on this occasion, that part of the acid, by the intervention of which this oil is separated, unites therewith; and, to the greater or smaller quantity of the acid thus combined with the oil, he imputes its being more or less ponderous: which is the more probable, as the heaviest oil is always obtained from a mixture in which the acid bears the greatest proportion; and *vice versa*. Perhaps the different specific gravity of essential oils is wholly owing to the greater or smaller quantity of acid they contain.

Mr. Hoffman hath made several observations on this oil, which evidently prove that it contains much acid. He says, that, if it be kept for some time in a bottle, it grows red, and loses its transparency; that its agreeable aromatic taste becomes acid and corrosive; and that if you hold it over the fire in a silver spoon, it corrodes it, and leaves a black spot on it; and that it also corrodes mercury, when heated therewith in a matrafs. To this Mr. Pott adds that it makes a very perceptible effervescence with fixed alkalis: and that being rectified by those salts it loses all the acid properties observed by Mr. Hoffman.

Mr. Hellot obtained a still more considerable quantity of this oil, by adding three or four ounces of a fat oil to the mixture of spirit of wine with the vitriolic acid. Now, as the oil we are speaking of hath the properties of essential oils, and is soluble in spirit of wine, Mr. Hellot observes that oil of vitriol by uniting with fat oils converts them into essential oils: which agrees very well with our opinion concerning the cause of the solubility of oils in spirit of wine; which, in the memoir alrea-

dy referred to on other occasions, we attribute to an acid superficially and slightly united with oils.

The oil which thus rises, in distilling spirit of wine mixed with the vitriolic acid, is known by the name of the *sweet spirit of vitriol*. This name is very improper, because it may suggest a notion that this oil derives its origin from the vitriolic acid, as some chymists have erroneously thought; whereas it comes entirely from the spirit of wine, as we have shewn. If any reason can be assigned for keeping up the name, it must be because of the considerable quantity of the vitriolic acid that remains in the combination, and is dulcified by its union with the spirit of wine.

This oil is an ingredient in Hoffman's famous *anodyne mineral liquor*. That liquor is thought to be nothing but this very oil dissolved, and combined with the two liquors that rise first in the distillation, and immediately before the sulphureous acid phlegm. It dissolves very easily and quickly in those spirituous menstruum: so that, if you intend to have it by itself, and to prevent its recombining with the liquors that come off before, (which should be prevented, because it hinders the separation of the æther,) you must take great care to change the receiver as soon as the acid phlegm with which it rises, begins to appear.

We have seen that, by the methods which Mr. Hellot hath pointed out, this sweet oil of vitriol may be increased, both in weight and quantity. In that ingenious chymist's memoir we also find some methods of preventing it from rising in the distillation. They consist wholly in the addition of some absorbent bodies, which, he tells us, divert the action of the vitriolic acid, at least in some measure, from the inflammable part of the spirit of wine. One of these methods is as follows.

“ Put into spirit of wine as much soft soap as it can dissolve: filter it, and pour on it some of

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the heaviest and most concentrated oil of vitriol: shake the mixture. The soap will be instantly decomposed, and its oil will float on the surface; because the vitriolic acid robs it of the alkali, which renders it miscible with spirit of wine. Distill it, and you will obtain but a very little of Rabel's water; which moreover will have the disagreeable smell of a most rancid oil. There will afterwards ascend a great quantity of spirit of wine having the same smell; then an aqueous, acid, and sulphureous liquor; but not a drop of yellow oil. Mean time there forms a bituminous fungus, of some consistence, rising above the oil of the soap which floats on the rest of the liquid."

Most of the vitriolic acid having been absorbed by the alkali of the soap, in this experiment, as Mr. Hellot observes, it is not surprising that it should not act upon the spirit of wine with so much efficacy as to decompose it, and separate its oil. For the same reason but a little of Rabel's water comes over, and almost all the spirit of wine rises without undergoing any sensible alteration. The disagreeable smell of these liquors comes from the oil of the soap, which, being naturally heavy, remains behind in the retort, where it grows rancid and is partly burnt.

The last experiment in Mr. Hellot's memoir, of which we shall take notice, is a peculiar process for preparing æther; by means whereof, with the help of an earthy medium, it is easy to distill the vitriolic acid spirit containing the æther, without any sensible change of smell from the beginning to the end of the operation; without its being succeeded by an acid sulphureous liquor, oil, black gum, resin, or bitumen; and without the necessity of taking any great care about the management of the fire, as the liquor may always be kept boiling in the retort, and distilled to dryness without any danger

danger. This medium is common potter's earth. Mr. Hellot puts six ounces thereof, well dried and pulverized, into a large retort, with one pound of spirit of wine and eight ounces of oil of vitriol. These he digests together three or four days. The mixture acquires no sensible colour. He sets the retort in a sand-bath, and continues the distillation to dryness with a moderate charcoal fire. Excepting a few drops that rise first, and which are pure spirit of wine, all the rest of the liquor that distills hath constantly the smell of æther; which is even somewhat more penetrating than that of the vinous acid spirit obtained without the intervention of this earthy medium.

We have shewn that the production of the æthereal liquor is owing to a semi-decomposition of the spirit of wine effected by the vitriolic acid during the distillation; that this acid continuing to act produces a total decomposition, or perfect separation of the oil and phlegm of the spirit of wine from each other; and that, the vitriolic acid, uniting with these two principles, forms the sulphureous phlegm, the fluid oil, and the bituminous matter, all frequently mentioned above. Why then, in this experiment of Mr. Hellot's, do we obtain only a spirit of wine replete with æther, while none of the other productions appear? The reason is a very natural one, and very clear: it is this; the potter's clay containing an earth of that kind which we called absorbent, because it possesses the property of uniting with acids, that earth joins with the vitriolic acid in the mixture, reduces it to a neutral salt, and thereby prevents its continuing to act upon the spirit of wine, as is necessary to the total decomposition thereof.

Mr. Hollot says on this occasion " that part of
" the vitriolic acid turning its action on this solu-
" ble earth or bole, which it finds in the potter's
" clay, ceases to act on the inflammable principle

“ of the spirit of wine ; that, consequently, as
“ there is not an immediate and continuous com-
“ bination of these two substances, neither a resin
“ nor a bitumen can result therefrom. This is so
“ true that a great part of the oil of vitriol may be
“ afterwards recovered from the potter's clay as
“ colourless as when it was first used.”

Mr. Hellot makes use of the following method
for procuring the æther from the acid vinous spi-
rit obtained by this distillation. “ You must, says
“ he, put all this liquor into a glass body, made
“ of one piece with its head; pour upon it, through
“ the hole in the upper part of the head, twice or
“ thrice as much well-water, the hardest to the
“ taste, and the most impregnated with gypsum,
“ that can be got. Very pure water, he observes,
“ produces much less æther.

“ If the vinous acid spirit have such a sulphure-
“ ous smell, as to occasion a suspicion that it con-
“ tains a little too much of a volatile vitriolic acid,
“ you must add to the water two or three drams of
“ salt of potash to absorb that acid; and then dis-
“ till with a lamp-heat.

“ While any true æther remains in the mixture,
“ you will see it ascend like a white pillar issuing
“ from the midst of the liquor, and consisting of
“ an infinite number of air bubbles inexpressibly
“ small. Nothing seems to condense in the cavity
“ of the head, which always remains clear, and
“ without any visible humidity. The gutts which
“ light on the sides of the receiver, instead of
“ forming a net-work thereon, as spirit of wine
“ doth when it is a little aqueous, spread to the
“ breadth of two inches or more, when they con-
“ sist of true æther. As soon as you perceive this
“ track begin to grow considerably narrower, the
“ fire must be put out; for what rises afterwards
“ will be mixed with water, and communicate that
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“ fault

“ fault to the æther already collected in the receiver.

“ Then pour this æthereal liquor into a long bottle, and add to it an equal quantity of well-water. Shake the bottle; the liquor will become milky, and the true æther will instantly separate, float upon the water, and mix no more with it. Separate it then by a siphon, and keep it in a glass bottle shut close with a glass stopple.”

PROCESS II.

Spirit of Wine combined with Spirit of Nitre. Sweet Spirit of Nitre.

INTO an English retort of crystal glass put some highly rectified spirit of wine; and, by means of a glass funnel with a long pipe, let fall into your spirit of wine a few drops of the smoking spirit of nitre. There will arise in the retort an effervescence attended with heat, red vapours, and a hissing noise like that of a live coal quenched in water. Shake the vessel a little, that the liquors may mix thoroughly, and that the heat may be equally communicated to the whole. Then add more spirit of nitre, but in a very small quantity, and with the same precautions as before. Continue thus adding spirit of nitre, by little and little at a time, till you have put into the retort a quantity equal to a third part of your spirit of wine. Let this mixture stand quiet, in a cool place, for ten or twelve hours; then set it to digest in a very gentle warmth for eight or ten days, having first luted on a receiver to the retort.

During this time a small quantity of liquor will come over into the receiver, which must be poured back into the retort. Then distill with a somewhat

what stronger degree of heat, but still very gently, till nothing be left in the retort but a thick matter. In the receiver you will find a spirituous liquor of a quick grateful smell, which will excite any corrosive acrimony. This is *the sweet spirit of nitre*.

OBSERVATIONS.

By this operation spirit of nitre is combined with spirit of wine; these two liquors being united with each other, much in the same manner as the vitriolic acid is with spirit of wine Rabel's water.

The proportion of the liquors which form this combination is not absolutely determined, and the several authors who have written on this subject differ much about it. Some require equal parts of the ingredients; others again from two as far as ten parts of spirit of wine to one of spirit of nitre. This depends on the degree to which the spirit of nitre made use of is concentrated, and on the greater or less acidity which your dulcified spirit of nitre is intended to have.

The Dispensatory of the College of Paris orders one part of spirit of nitre distilled from dried clay, that is, of spirit which doth not smoke, to be mixed with two parts of rectified spirit of wine, and the whole to stand in digestion for a month, without distilling the mixture at all. This is a very good method: because the long digestion supplies the place of distillation, and the spirit of nitre, not being highly concentrated, doth not greatly alter the spirit of wine; besides that many inconveniences, to be presently taken notice of, are by this means avoided.

But as our design is not to describe such chymical preparations only as are commonly used in medicine, our plan requiring us to treat particularly of those which may give any light into the fundamental properties of bodies, the process here set

down appeared the fittest for our purpose ; because the action which spirit of nitre exerts upon spirit of wine is therein stronger and more perceptible.

One of the first particularities, attending the mixture of those two liquors, is the great effervescence, accompanied with violent heat, abundance of fumes, and loud hissing, which arises as soon as the spirit of nitre and the spirit of wine come into contact with each other. There is great reason to think that these phenomena are produced only by the rapidity and vigour with which the nitrous acid rushes into union with the inflammable part of the spirit of wine. We observed, in treating of the æther, that phenomena of the same kind appear at the instant when the vitriolic acid unites with spirit of wine : but on that occasion, how highly soever the vitriolic acid be concentrated, all these effects are in a less degree than those produced in the present experiment ; because the nitrous acid, though weaker than the vitriolic, generally acts much more vigorously and violently on the bodies with which it unites, than any other sort of acid.

Concerning these mixtures of acids with spirit of wine Mr. Pott observes, that it is not a matter of indifference whether you pour the spirit of wine upon the acid, or the acid on the spirit of wine ; but that every thing passes much more quietly, when the acid is poured on the spirit of wine, than when the contrary is done : and he gives the true reason thereof ; to wit, that when the acid is poured on the spirit of wine it finds in that liquor a great quantity of water, with which it immediately unites ; that this weakens it, and hinders it from acting on the inflammable part with so much impetuosity as it otherwise would ; and therefore he advises that such mixtures be always made in this manner. But it is evident that this advantage is gained only by mixing the acid with the spirit of wine very gradually, and drop by drop, as directed in the

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process after Mr. Pott. For, if the two liquors were to be mixed together suddenly, and all at once, it is certain that the acid would not meet with a single drop of phlegm more or less in that way than in the other.

Therefore the chief, and, in some measure, the only precaution necessary to be taken, in the making of such mixtures, to prevent the violent effervescence and other inconveniences that may attend it, such as explosion, and the bursting of the vessels is, to pour but a very small quantity of one liquor into the other at a time, and to add no more till the effervescence, and even the heat, produced by the first portion, be entirely ceased. With these precautions you may proceed either way, and be always sure that your vessels will not burst; because it is in your power to add such a small quantity of liquor at a time, as shall scarce produce a sensible effervescence. We own, however, that Mr. Pott's observation is a very just one. There is even an advantage in pouring the acid on the spirit of wine, as he directs; which is, that the mixture is a little sooner made, and without any danger.

We have shewn that the vitriolic acid becomes aqueous and sulphureous by mixing spirit of wine with it: the nitrous acid is changed by this mixture in a manner no less remarkable. Mr. Pott observes that when spirit of nitre is dulcified, that is, when it is perfectly combined with spirit of wine, it loses the disagreeable odour peculiar to it, and acquires another that is quick and fragrant; it doth not afterwards emit any red fumes; it rises with a less degree of heat than when pure; it acts with less vigour on fixed alkalis and absorbent earths. Lastly, we shall here relate an experiment made by that chymist, which seems to prove that the nitrous acid loses its most characteristic properties, and entirely changes its nature, by being combined with spirit of wine.

Mr. Pott examined the thick liquor left in the retort, when the dulcified spirit of nitre is distilled off. By analyzing it he obtained an acid liquor, of a yellow colour, and of a somewhat empyreumatic smell. This acid was followed by some drops of a red empyreumatic oil; and there remained, at the bottom of the distilling vessel, a black, thin, charred matter, like that which remains after the first rectification of a fetid oil.

The oil extracted from this residue is a portion of that which helped to constitute the spirit of wine; being separated therefrom by the nitrous acid, in the same manner as that treated of in the preceding process, and called *sweet oil of vitriol*, is separated by the vitriolic acid. But as the nitrous acid, which is weaker than the vitriolic, doth not so effectually decompose the spirit of wine, the oil, obtained in the present experiment, is in smaller quantity, than that procured in the distillation of a mixture of the vitriolic acid with spirit of wine.

As to the acid which Mr. Pott drew off in his experiment, there is great reason to think it a part of that which was an ingredient in the mixture: namely, of the nitrous acid. And yet Mr. Pott having saturated with a fixed alkali one part of the residuum, which he had a mind to examine before the acid was separated from it by distillation, and expecting this matter to contain a regenerated nitre, he threw it on a live coal; but was surprised to see it burn without the least detonation; and thence concluded that the nitrous acid had changed its nature. This experiment, he thinks, may furnish hints for the transmutation of acids; and he is of opinion that the nitrous acid loses its virtue of detonating, in the present case, only because its inflammable part, to which it owes its distinguishing properties, hath deserted it, and joined with that of the spirit of wine.

Indeed if the acid obtained by Mr. Pott, which
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being reduced to a neutral salt doth not detonate, derives its origin from the nitrous acid that was combined with the spirit of wine, there is no doubt of its being depraved in a peculiar manner, and having entirely changed its nature. But may we not suppose it to have another origin? May it not be the acid of the spirit of wine itself, resulting from the decomposition of that mixt in the distillation?

Mr. Navier, whom we mentioned in our Elements of the Theory, extracted a very singular oily liquor from the mixture of spirit of wine and spirit of nitre, without distillation, and even without the help of fire. He put equal parts of the two liquors, by measure, not by weight, into a bottle, which he stopped close with a good cork, fastened down with a pack-thread. Nine days afterwards he found about a sixth part of the mixture separated from, and floating on, the rest of the liquor. This was a very fine æthereal oil, very limpid, and almost as colourless as water.

In another experiment Mr. Navier substituted a solution of iron in the nitrous acid for pure spirit of nitre; and with this solution he mixed an equal weight of spirit of wine. From the mixture, after a fermentation which appeared in it, he obtained by the same method an æthereal oil, like that of his former experiment; except that the latter, which was at first as colourless as the other, acquired a redness in the space of about three weeks. He conjectures, with probability, that this colour proceeded from some particles of iron which were united with it, and which gradually exhaled.

If a few drops of oil of tartar *per deliquium* be poured on this oil, as soon as it is separated, there appears at first no sensible change therein: but after some time needle-like crystals shoot in it, which are a true regenerated nitre; and if the bottle be then unstopped, the liquor emits a most pungent nitro-sulphureous odour; which leaves no doubt of

of this oil's containing a nitrous acid. When it is thus freed of its acid, by means of the oil of tartar it is much more volatile than before.

Neither the vitriolic nor the marine acid is capable of separating such an oil from spirit of wine; but the nitrous acid always produces it, even when it is not concentrated, and doth not smoke.

It is very certain that this oil derives its origin from the spirit of wine: but there are not yet experiments enough made upon it, to enable us to speak very accurately about the manner in which this liquor is formed, or of the cause of its separation from the spirit of wine.

P R O C E S S III.

*Spirit of Wine combined with the Acid of Sea-salt.
Dulcified Spirit of Salt.*

MIX together, little by little, in a glass retort, two parts of spirit of wine with one part of spirit of salt. Set this mixture to digest for a month in a gentle heat, and distill it, till nothing remain in the retort but a thick matter.

O B S E R V A T I O N S.

The acid of sea-salt is much less disposed to unite with inflammable matters than the other two mineral acids; and therefore, though it be ever so highly concentrated, when mixed with spirit of wine, it never produces an effervescence comparable to that which is produced by the spirit of nitre. Neither the proportion nor strength of the spirit of salt, requisite to prepare the sweet spirit of salt, are unanimously agreed upon by authors. Some direct equal parts of the two liquors; while others prescribe from two to four or five parts of spirit of wine

wine to one part of spirit of salt. Some use only common spirit of salt; others require the smoking spirit, distilled by means of spirit of vitriol. Lastly, some order the mixture to be distilled, after some days digestion; and others content themselves with barely digesting it. The whole depends on the degree of strength which the sweet spirit of salt is intended to have. This composition, as well as the sweet spirit of nitre, is esteemed in medicine to be very aperitive and diuretic.

When the mixture of spirit of salt and spirit of wine is distilled, there comes over but one liquor, which appears homogeneous. This is the sweet spirit of salt. The nature of the marine acid is not changed in this combination: the acid is only weakened and rendered more mild; but in other respects it retains its characteristic properties.

Some authors pretend that an oil is obtained by distilling the mixture for the sweet spirit of salt; but others expressly deny the fact. This variety may be occasioned by the quality of the spirit of wine employed. It would not be surprising if a spirit of wine, which contains much oil that is unnecessary to its nature, and, as it were, adventitious to it, should yield an oil when distilled with spirit of salt.

The thick residue, found in the retort after distillation, contains the most ponderous part of the acid, united with part of the spirit of wine. If the distillation be continued to dryness, there remains in the retort a black charred matter, much like that which is left by the combinations of spirit of wine with the other acids.

A sweet spirit of salt may be also prepared by digesting spirit of wine with, or distilling it from, metallic compositions replete with the marine acid adhering but slightly to them; such as corrosive sublimate, and butter of antimony. Part of this acid, which is very highly concentrated, quits the metallic

metallic substance with which it is superficially combined, in order to unite with the spirit of wine. If butter of antimony be used for this purpose, Mr. Pott, the author of these experiments, observes that a *mercurius vitæ* precipitates, which is nothing else, as we observed in its place, but the reguline part of the butter of antimony deserted by its acid.

PROCESS IV.

Oils, or oily matters, that are soluble in Spirit of Wine, separated from Vegetables, and dissolved by means of that Menstruum. Tinctures; Elixirs; Varnishes. Aromatic Strong Waters.

PUT into a matrafs the substances from which you intend to extract a tincture, having first pounded them, or pulverised them if they are capable of it. Pour upon them spirit of wine to the depth of three fingers breadth. Cover the matrafs with a piece of wet bladder, and tie it on with packthread. Make a little hole in this bit of bladder with a pin, leaving it in the hole to keep it stopped. Set the matrafs in a sand-bath very gently heated. If the spirit of wine dissolve any part of the body, it will accordingly acquire a deeper or lighter colour. Continue the digestion till you perceive that the spirit of wine gains no more colour. From time to time pull out the pin, to give vent to the vapours, or rarefied air, which might otherwise burst the matrafs. Decant your spirit of wine, and keep it in a bottle well corked. Pour on some fresh spirit in its stead; digest as before; and go on in this manner, pouring on and off fresh spirit of wine till the last come off colourless.

OBSERVATIONS.

It is commonly said that spirit of wine is the solvent of oils and oily matters : but this proposition is too general ; for there are several sorts of oils and oily matters which this menstruum will not dissolve. Of this number are the fat oils, bees-wax and the other oily compounds of that kind, Properly speaking, it dissolves but two sorts of oily substances ; namely, essential oils, and balsams or resins, which are matters of the same kind, differing from each other only as they are more or less thick ; and oils that are in a saponaceous state.

In our Elements of the Theory we have explained our opinion on this head, from a memoir on the subject printed among those of the academy for 1745. To repeat it in a few words : we take the cause of the solubility of oils in spirit of wine to be an acid, which is but superficially united with them, and so as still to retain its properties.

The principal proofs on which we found this opinion are drawn from that property of essential oils, balsams, and resins, which are naturally soluble in spirit of wine, that they become so much the less soluble in this menstruum, the oftener they are distilled or rectified ; and from that property which fat oils, or other oily matters, naturally indissoluble in spirit of wine, possess, of becoming more and more soluble therein the oftener they are distilled. We shewed that distillation lessens the solubility of essential oils, balsams, and resins, only by depriving these substances of part of the manifest acid which they contain, and which is the cause of their solubility ; and that fat oils, and other oily matters, naturally indissoluble in spirit of wine, are by the same operation rendered capable of dissolving therein, only because it discovers, and partly extricates, an acid, which is naturally combined with

with them so intimately that it is entirely deprived of action, and all its properties perfectly masked. If these principles be well-attended to, and if it be recollected withal, that spirit of wine unites with water preferably to oils; insomuch that, if it be mixed with water when it hath dissolved an oil, it quits the oil to unite with the water; that for the same reason it is not capable, when very aqueous, of dissolving any oil, seeing that, as oil and water are not susceptible of contracting any union, it must then desert its phlegm to unite with the oil; which it cannot do, because it hath a greater affinity with phlegm than with oil; and, lastly, that if oil be combined with any saline substance, which makes it soluble in water; that is, if it be in a saponaceous state, it will then remain dissolved in spirit of wine, without being precipitated by water, or will be dissolved by a very aqueous spirit of wine, and frequently much better than by a highly rectified spirit: if these things, I say, be considered, we shall easily perceive what must be the effect of digesting spirit of wine with any vegetable substance whatever.

Spirit of wine dissolves all the essential oil, balsam, and resin contained in any vegetable; and as these matters are not soluble in water, they may be separated from the spirit in which they are dissolved, by lowering it with much water. It instantly becomes white and opaque, like milk; the oily parts gradually unite, and form considerable masses, especially if they be resinous. This is the method commonly made use of to extract the resins of scammony, jalap, guiacum, and several other vegetable substances, which it would be difficult to procure by any other means.

If the matters digested with spirit of wine contain any saponaceous juices, the spirit will take up those juices also. But as soaps are soluble in water, as well as in spirit of wine, they cannot be separated,

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rated, by the addition of water, from the spirit in which they are dissolved. Whatever quantity of water therefore you mix with a spirit that is impregnated with such juices, no separation thereof will be produced; and for the same reason the saponaceous matters will be dissolved by a very aqueous spirit of wine.

Spirit of wine impregnated with such parts of any vegetable substance, as it is capable of dissolving, is commonly called a *tincture*. Several tinctures mixed together, or a tincture drawn from sundry vegetable substances at the same time, and in the same vessel, take the name of an *elixir*. Tinctures or elixirs impregnated with resinous matters only are true *varnishes*. All these preparations are made in the same manner; to wit as directed in our process. We shall only add here that if the substances from which a tincture or elixir is to be made contain too much moisture, it is proper to free them from it by gentle desiccation; especially if you design that the tincture should be well impregnated with the oily and resinous parts for their excess of moisture uniting with the spirit of wine would weaken it, and render it unable to act on those matters, which it cannot dissolve when it is aqueous.

Vegetable substances which have been repeatedly digested with different parcels of spirit of wine, till the last would extract nothing, are deemed to be exhausted of all their essential oils, and saponaceous juices: but if they contain moreover any fat oil, wax, or gum, these principles will still remain therein after the digestion, in the same quantity as before; because spirit of wine is incapable of dissolving them.

With regard to the fat oil and wax, this is not at all surprising: we have explained in another place why these matters are indissoluble by ardent spirits, but as for the gum, it would seem, ac-

according to the general principles abovementioned, that it should be soluble in that menstruum, even with more ease than resins; as it consists almost entirely of water, with which spirit of wine is known to unite more easily than with oils. Indeed there is also a little oil in its composition: but this oil seems to be in a perfectly saponaceous state; for gum dissolves wholly and easily in water, without lessening its transparency in the least.

I own that it is extremely difficult to give a very satisfactory account of this matter. We may however venture to throw out some conjectures concerning it, deduced from what hath been already said, relating to the cause of the solubility of oils in spirit of wine. We shewed that the oils which dissolve in this menstruum derive that property from a manifest acid, which is united with them but superficially, and in such a manner as to retain all its virtue; but that if this same acid be too intimately united with the oil, so as to have no manifest power, but be in a manner destroyed, and, converted as it were into a neutral salt, it will not then produce this effect.

A modern author * relates two experiments which agree very well with this opinion, and indeed confirm it. He mixed together oil of vitriol and oil of turpentine, with a view to imitate by art a bituminous matter; which, we know, is not at all, or at least scarcely, soluble in water. These two matters being united together produced a red thick compound, which by evaporation became like a natural bitumen.

The author observes that when this mixture is just made it dissolves in alkohol; but that in some time it changes its nature, and communicates scarce any part of its substance to that solvent. Now

whence

* Mr. Fadows, in a little English book, entitled *The Modern Apothecary*.

whence can such a difference arise, but from this, that when the mixture is new, the acid is as yet but superficially united with the oil, and combines with it more and more intimately, as the mixture grows older.

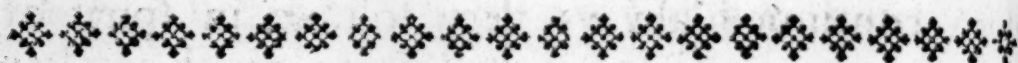
The same author, having repeated the experiment with spirit of vitriol, obtained a compound which continued always very soluble in spirit of wine; because spirit of vitriol being much weaker and more aqueous than oil of vitriol, was incapable of combining so closely with the oil of turpentine, as that concentrated acid did in the former experiment. By the by, there is great reason to believe that the very intimate union of a mineral acid with an oily matter is the true cause why bitumens will not dissolve in spirit of wine.

It seems therefore pretty probable that the acid which makes the oil of gummy matters soluble in water, and reduces it to a saponaceous state, is so intimately united with that oil, that it loses its properties, and is in a manner converted into a neutral salt. Now we know that such salts are soluble in water, but are not so, for the most part, in spirit of wine.

If your tinctures or elixirs be not so strong or so saturated as you desire, you may by distillation abstract part of the spirit of wine which they contain, and by that means give them such a degree of thickness as you judge proper. But the spirit of wine thus drawn off constantly carries along with it a good deal of the aromatic principle. It is a truly *aromatic strong water*. This spirit of wine also carries up with it a portion of thin oil, which is so much the more considerable as the degree of heat employed is greater: and this is the reason why it becomes of a milky colour when mixed with water.

If you intend to make an aromatic strong water only, you need not previously extract a tincture,

from the vegetable substance with which you mean to prepare your water ; you need only put it in a cucurbit, pour spirit of wine upon it, and distill with a gentle heat. By this means you will obtain a spirit of wine impregnated with all the odour of the plant..



CHAP. III.

OF TARTAR.

PROCESS I.

Tartar analyzed by distillation. The Spirit, Oil, and Alkaline Salt of Tartar.

INTO a stone retort, or a glass one coated with lute, put some white tartar broken into small bits ; observing that one half, or at least a full third of the vessel be left empty. Set your retort in a reverberating furnace. Fit on a large ballon, having a small hole drilled in it ; lute it exactly with fat lute, and secure the joint with a linen cloth smeared with lute made of quick-lime and the white of an egg. Apply at first an exceeding gentle heat, which will raise a limpid, sourish, pungent water, having but little smell, and a bitterish taste.

When this first phlegm ceases to come off, increase your fire a little, and make the degree of heat nearly equal to that of boiling water. A thin limpid oil will rise, accompanied with white vapours, and with a prodigious quantity of air, which will issue out with such impetuosity, that if you do not open the little hole in the receiver time enough to give it vent, it will burst the vessels with explosion. An acid liquor will rise at the same time.

Continue

Continue the distillation, increasing the heat by insensible degrees, and frequently unstopping the little hole of the receiver, till the elastic vapours cease to issue, and the oil to distill.

Then raise your fire more boldly. The acid spirit will continue to rise, and will be accompanied with a very black, fetid, empyreumatic, ponderous, and very thick oil. Urge the fire to the utmost extremity, so that the retort may be of a perfect red heat. This violent fire will raise a little volatile alkali, besides a portion of oil as thick as pitch. When the distillation is finished, you will find in the retort a black, saline, charred matter, which grows hot when wetted, attracts the moisture of the air, runs *per deliquium*, and hath all the properties of a fixed alkali.

This mass, being exposed to a naked fire in the open air, burns, consumes, and is reduced to a white ash, which is a fiery, caustic, fixed alkali.

OBSERVATIONS.

The matters qualified to produce a spirituous liquor by fermentation do not all contain the just and accurate proportion of acid necessary to constitute an ardent spirit. Many of them, the juices of fruits for instance, and especially that of the grape, are replete with a super-abundant quantity of acid, more than concurs to form that product of fermentation. This super-abundant acid, combined with some of the oil and earth contained in the fermented liquor, produces a sort of salt, which hangs for a while suspended in that liquor, but after some time, when the wind stands quiet in a cool place, separates from it, and forms a stone-like incrustation on the inside of the vat in which the wine is kept. This matter is called *tartar*.

The lees of wine resemble tartar, in as much as they contain, and yield when analyzed the same principles;

principles ; but they differ from it in this, that they contain, moreover, a greater quantity of earth, of phlegm, and a little ardent spirit, which are only mixed, but not united, with the tartarous acid.

The residue, or sort of extract, which remains in the cucurbite after wine hath been deprived of its ardent spirit by distillation, hath also a great conformity with tartar. It even contains that portion of tartar which remained suspended in the wine at the time of its distillation : and accordingly this residue of wine, being analyzed, yields the same principles with tartar.

Hence we see that liquors, which have undergone the spirituous fermentation, consist of an ardent spirit and a tartarous acid suspended in a certain quantity of water.

In the analysis of tartar there are several things worthy of notice. The first is the vast quantity of air that this mixt body yields when it begins to be decomposed. The chief difficulty attending its analysis arises from this air ; which issues out and exerts its elastic force with such impetuosity, that all the precautions above-mentioned are no more than necessary to prevent the burstings of the vessels.

The singular nature of the thin limpid oil, which rises with this air, after the first acid phlegm, deserves likewise our particular attention. This oil is one of the most penetrating we know. Boerhaave, who distilled tartar without having a vent-hole in his receiver, was obliged, in order to prevent its bursting, to apply it to his retort with a lute so weak that most of the elastic vapours might perspire through it ; and he observed, that, though the neck of his retort entered above five inches into the mouth of his receiver, and was luted on as closely as possible with such a lute, yet this light oil of tartar constantly returned back again, as it were, and pervaded the substance of the lute, so that a good deal of it dropped into a dish placed

on the outside on purpose to receive it. This oil is probably rendered so active and subtile, only by having been exceedingly attenuated by the fermenting motion. This experiment is one of those which sufficiently prove the necessity of employing receivers having a small vent-hole, that may be opened and shut as occasion requires.

The last remark we shall make, on the productions of tartar by distillation, relates to the *caput mortuum* found in the retort when the operation is finished. This residue is very different from that which other vegetable matters afford: for, when they are decomposed in close vessels, they leave nothing but a mere charred matter, in which no saline property appears, and from which no fixed alkali can be obtained, but by carrying their analysis to the utmost; that is, by burning them in the open air. Tartar on the contrary, only by being distilled in close vessels, without burning it afterwards in the open air, is changed into a substance which hath all the properties of a fixed alkali. This is probably owing to the tartar's containing the principles requisite to form a fixed alkali in a much greater quantity than they are to be found in any other substance. As tartar thus alkalized in close vessels still contains much inflammable matter, it might be employed with advantage as a reducing flux in several operations of metallurgy.

Of all the vegetable matters we know, calcined tartar yields the greatest quantity of fixed alkali; which is likewise very pure, and therefore much used in chymistry.

Burnt lees of wine also afford a great quantity of fixed alkali, which is of the same nature with that of tartar. This salt is used in different trades, and particularly in dying. The French vinegar-makers collect quantities of these lees, which they make up into cakes and dry: while it is in this state

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state they call it *gravelle* or *gravelée*; and *cendre gravelée* when it is burnt.

If the extract of wine, which remains after the spirit is drawn off, be gently evaporated to dryness, and that dry matter burnt like tartar or *gravelle* it will make a sort of *cendre gravelée* very rich in alkaline salt.

PROCESS II.

The Depuration of Tartar. Cream and Crystals of Tartar.

REDUCE to a fine powder the tartar you intend to purify, and boil it in twenty five or thirty times as much water. Filter the boiling liquor through a flannel bag, and then gently evaporate some part of it: there will soon form on its surface a saline crust, which is the *cream of tartar*. Let your liquor cool, and there will adhere to the sides of the vessel a great quantity of a crystallized saline matter, which is *crystal of tartar*.

OBSERVATIONS.

Tartar, when taken out of the vats in which it forms, is mixed with a considerable quantity of earthy parts, which are not intimately united therewith, but adulterate it. This extraneous earth makes about two fifths of the whole weight of common tartar; but white tartar, which is the best, contains but about a third part of earth.

The method of refining tartar, and freeing it from this adventitious earth, is very simple, as appears from the process. Earthy matters, which are not intimately combined with an acid in the form of a neutral salt, are not dissoluble in water: for which reason the water, in which crude tartar is boiled

boiled, dissolves the saline part only, which passes with it through the filter; but doth not dissolve the earth of the tartar, because that earth is not combined with the saline part, and so being only suspended in the liquor remains on the filter.

The saline parts of the tartar, though they are now separated from the gross earth with which they were mixed, are not yet perfectly pure. These first crystals of tartar have a disagreeable ruffet colour, and are not transparent: this is owing to their being coated over, as it were, with a fatty matter, which is also foreign to their nature, and may be separated from them without decomposing them in the least.

The crystals of tartar are but seldom perfectly depurated in chymical laboratories; because the operation doth not usually succeed well on small quantities: but there are manufactories which do it by the great, and supply the chymists, as well as the several tradesmen, with very fine and very pure crystals of tartar. These manufactories are chiefly set up in the neighbourhood of Montpellier. Mr. Fises, a celebrated professor of medicine, hath in the memoirs of the academy for 1725 described the operation as performed in one of these works. He tells us that having separated the earthy part from the crystals of tartar, by boiling and filtering, they dissolve them again, and boil them in large caldrons, mixed with a white saponaceous earth, which cleanses and whitens them to perfection.

The saponaceous earth is found near the works; but it is not the only one that may be employed for this purpose; since, as Mr. Fises observed, they have successively made use of several different earths in that very work, and that the earth they now use hath not been long employed. There is reason to think that most saponaceous earths might answer the purpose of refining crystal of tartar: but one necessary condition is that they be altogether indissoluble

soluble by crystal of tartar, which being acid dissolves many sorts of earth ; for, if they have not this quality, they will form a neutral salt with the saline part of the tartar, the nature of which they will intirely change, and convert it into soluble tartar, as will appear by the experiments that follow.



C H A P. IV.

CRYSTAL OF TARTAR COMBINED WITH SEVERAL SUBSTANCES.

P R O C E S S I.

Crystal of Tartar combined with Absorbent Earths. Soluble Tartars.

BOIL an absorbent earth, such as chalk, in a pan with water ; and, when you perceive the earth thoroughly divided, and equally distributed through the water, throw into a pan, from time to time, some pulverized crystal of tartar, which will excite a considerable effervescence. Continue these projections, till you observe no effervescence excited thereby. All the absorbent earth, which obscured the transparency of the water, and gave it an opaque white colour, will gradually disappear as the crystal of tartar combines with it ; and when the combination is perfected, the liquor will be clear and limpid. Then filter it, and there will be left on the filter but a very small quantity of earth. Evaporate all the filtered liquor with a gentle heat ; and then set it in a cool place to shoot. Crystals will form therein, having the figure of flat quadrangular prisms, with almost al-

ways

ways one, sometimes two, of the angles of the prism shaved down, as it were; and then the surfaces at each end are oblique, answering to those depressed angles. These crystals are a neutral salt, which readily dissolves in water in a true *soluble tartar*.

OBSERVATIONS.

Crystal of tartar is a saline substance of a singular nature. Though it crystallizes like a neutral salt, yet it is not one: it hath only the form of one; its principal properties being those of an acid. Nevertheless it is not a pure acid; for it is united with a certain quantity of oil and of earth, which give it the property of crystallizing, and it is scarce dissolvable in water. It is a middle substance between an acid and a neutral salt. It is an acid half-neutralized; on which account it is capable of acting like an acid on all substances soluble by acids, and so of being converted into a perfectly neutral salt by combining with them to the point of saturation.

In the experiments made to neutralize crystal of tartar, fixed alkaline salts alone were formerly used. Mess. Duhamel and Grosse were the first who discovered that absorbent earths might be substituted for alkalis, and would produce nearly the same effects on crystal of tartar. The experiments made by these two academicians in conjunction are circumstantially related in two curious memoirs on this subject, given in by them jointly, and printed with those of the academy for 1732 and 1733. From these memoirs we took the process here given, and shall also borrow from thence most of the remarks we are now going to make.

Stone-lime holds, as it were, the middle place between mere absorbent earths and fixed alkalis. Now, seeing crystal of tartar may be converted in-

to a neutral salt by either of these two substances, it follows that lime ought to produce the same effect upon it. Accordingly Mess. Duhamel and Groffe found it to be so upon trial; have formed, with *lac calcis* and crystal of tartar, a neutral salt perfectly like that which results from the union of that saline matter with chalk. *Cremor calcis*, or that salino-terrene pellicle which forms on lime-water, produced the same effect: but, what is most singular is, that lime-water itself, though it be clear and limpid, and consequently doth not seem to contain any earthy particles, produced nevertheless a great effervescence with crystal of tartar, and neutralized it as perfectly as *cremor calcis*, or water ever so much impregnated with chalk. This arises from hence that a great quantity of the salino-terrene matter, which forms the *cremor calcis*, is dissolved in the lime-water.

Though lime-water neutralizes crystal of tartar as perfectly as chalk does, and though the crystals of soluble tartar, or neutralized tartar, thereby produced, be like those which have chalk for their basis, yet Mess. Duhamel and Groffe observed some differences, worthy of notice, between the phenomena accompanying the production of these two natural salts, which resemble each other so much that they seem but one and the same species of salt. The principal difference consists in this, that the water containing the tartar neutralized by chalk is very limpid, and leaves but a very small quantity of earth on the filter; whereas the lime-water, with which tartar hath been neutralized, leaves on the filter a considerable quantity of earth.

This must appear the more surprising that the water replete with chalk was, before its union with the crystal of tartar, turbid and opaque; whereas the lime-water was at first clear and limpid. Mess. Duhamel and Groffe suspect this to arise from hence, that the effervescence excited, while the

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crystal of tartar dissolves the matter contained in lime-water, is greater than that which is produced by its union with chalk suspended in water.

“ If we consider, say they, that in a great effervescence a considerable quantity of the acid spirit is evaporated, we shall easily perceive, that, the more of that spirit escapes, the more of the earth of the tartar will be precipitated. Now, as the effervescence with lime-water is more considerable, and as there is less alkaline earth to check, as it were, and restrain the acid, than in the experiment with chalk, a greater quantity of the acid spirit may escape ; which being entirely lost will cause more earth to precipitate in this case than in the other, where the acid is all at once attracted by a great deal of alkaline earth : and accordingly this was the reason that our tartar dissolved by chalk deposited, in crystallizing, a grey earth, which was scarce perceivable in the experiment made with lime-water.

“ Yet perhaps, say they, an acid, which we suspect to be contained in lime, may have partly occasioned the precipitation of this earth.” The existence of this acid, which these gentlemen at that time only suspected, hath been since demonstrated by several experiments, and particularly by those which Mr. Malouin hath published. This acid is the vitriolic, which, in combination with some of the earth of the lime, forms a sort of selenitic salt ; which adds greatly to the probability of Mess. Duhamel and Grosse's last conjecture. I shall now explain how I conceive the vitriolic acid in lime may occasion the copious precipitate which falls in lime-water, when crystal of tartar is neutralized by it.

The quantity of vitriolic acid contained in lime is very inconsiderable ; so that to convert it into a neutral salt requires its intimate union with a very small quantity of the earthy and absorbent parts.

Hence it comes to pass, that, when water is poured upon quick lime, in order to make lime-water, it in some sort divides the lime into two parts. All the particles of absorbent earth, which had not contracted an union with the acid, are at first barely suspended in the liquor, the transparency of which they destroy, giving it an opaque white colour; and this is what makes the *lac calis*: but they soon separate from it, and fall to the bottom, in the form of a precipitate; because they are not soluble in water. By this precipitation the liquor becomes limpid, and remains impregnated only with such of the earthy parts as are united with the vitriolic acid, in the form of a kind of neutral salt, and have by that union acquired solubility. But the vitriolic acid finding many more absorbent parts in the lime than were necessary to neutralize it, in a manner over-dosed itself with earthy parts, and thereby exceeded the bounds of a perfect neutrality.

On the other hand, it hath been shewn that crystal of tartar is an imperfect neutral salt. Now these two salts, which are neither of them perfectly neutral, differ from a perfectly neutral salt by properties directly opposite to each other; seeing the selenitic matter in lime exceeds in it's absorbent or alkaline quality, and crystal of tartar exceeds, on the contrary, in acidity.

What must be the consequence, therefore, of mixing these two saline matters together? The same as when an acid is mixed with a fixed alkali; that is the salt which exceeds in acidity will combine with the super-abundant alkaline earth of the selenitic salt; so that these two saline matters will both become perfectly neutral salts. Yet these two neutral salts have not the same degree of solubility in water. The neutralized crystal of tartar dissolves very readily in water, and is for that reason called soluble tartar: the selenitic salt, on the contrary, is hardly dissolvable in it at all. Now it is a rule that,

that, when two salts of this nature meet together, the most soluble always remains united with the water, exclusive of the other, which is forced to precipitate. This I imagine to be what happens in the present case; and the precipitate which we see fall, in the lime-water employed to neutralize crystal of tartar, seems to me to be no other than the selenitic salt of the lime; which, being less soluble than the neutralized tartar, gives place to it, and separates from the liquor.

Indeed we cannot, in my opinion, account for the precipitate under consideration, any other way, than by supposing it to be a portion either of the earth of the crystal of tartar, or a portion of the lime. Now, either of these earths is dissolvable by acids; whereas the precipitate in question, according to the observations of Mess. Duhamel and Grosse, is not so: and this ought to be the case, if the precipitate be nothing but the selenitic salt of the lime, which being a neutralized salt, partly constituted by the most powerful of all the acids, must be unalterable by any acid whatever.

Mess. Duhamel and Grosse made a great many experiments on the combinations of crystal of tartar with different sorts of earths. The result of the whole is, that there are some earths which this acid dissolves, and which contract such an union with crystal of tartar, that they not only change its external character, that is, its tendency to crystallize, and its indissolubleness in cold water, but also entirely alter its taste and other qualities. In a word, those earths produce on this salt all the effects of alkaline salts. These earths are such as are called absorbent earths; stone-lime, animal-lime, cretaceous earths, a portion of calcined gypsum, and of potash; in short, all such as distilled vinegar is capable of dissolving: this is the mark by which those earths, which are qualified to neutralize crystal of tartar and to render it soluble, may be distinguished.

Mess. Duhamel and Groffe found also upon trial that there are other earths, on the contrary, which are, in a manner, inaccessible to the acid of crystal of tartar; that they take up, indeed, the grossest and redundant oil of the tartar, but without affecting its saline part at all: and if these earths are ever observed to form any union with the crystals of tartar, as happens in the refineries near Montpellier, that union is only superficial, not intimate; and therefore it alters none of the characters of the salt. Among these earths are the clayey, bolar, sandy earths, and others of that kind. Hence Mess. Duhamel and Groffe conclude, that these are the earths which ought to be employed in the purification and whitening of crystal of tartar. Vinegar is here also the test by which it may be known whether an earth intended for this purpose be fit for it: for you may be sure that it will form no union with crystal of tartar, if the acid of vinegar be incapable of dissolving it.

PROCESS II.

Crystal of Tartar combined with fixed alkalis. The Vegetable Salt. Saignette's Salt. The decomposition of Soluble Tartars.

IN eight parts of water dissolve one part of a very pure alkaline salt, perfectly freed from the phlogiston by calcination. Heat this lixivium in a stone pan set on a sand-bath, and from time to time throw into it a little powdered cream or crystal of tartar. Each projection will excite a great effervescence, attended with many bubbles, which will rise to a considerable height one over the other. Stir the liquor when the effervescence ceases, and you will see it begin again.

When no effervescence appears upon stirring the liquor,

liquor, add a little more cream of tartar, and the same phænomena will be renewed. Go on thus till you have obtained the point of perfect saturation.

Then filter your liquor. If the alkali you made use of was the salt of Soda, evaporate your liquor quickly to a pellicle, and there will shoot in it crystals of nine sides resembling a coffin; the bottom part thereof being concave, and streaked with a great many parallel lines; and this is *Saignette's salt*. If you have employed any other alkali but soda, or the basis of sea-salt, evaporate your liquor slowly to the consistence of a syrup: let it stand quiet, and there will form in it crystals having the figure of flatted parallelopipeds; and this is the *vegetable salt*, or *tartarized tartar*.

OBSERVATIONS.

Seeing pure absorbent earths are capable of neutralizing crystal of tartar, and converting it into soluble tartar, there is still more reason to expect that fixed alkalis should possess the same property, as they have a much greater affinity with acids: and accordingly crystal of tartar always forms, with every species of these salts, a neutral salt which is a soluble tartar.

A soluble tartar, formed by the union of crystal of tartar with tartar converted into an alkali by fire, hath been long used in medicine as a gentle saponaceous purgative, known by the names of *Tartarized Tartar* or the *Vegetable Salt*. But the soluble tartar, prepared by combining crystal of tartar with the alkali of soda, which, as we remarked before, is analogous to the basis of sea-salt, and different from all other alkalis, was not well known to chymists till the year 1731, when M. Boulduc published the preparation in a memoir

printed with the academy's collection for that year *.

Not but that it was very much used before that time: for it had been for several years in high reputation, and prescribed instead of tartarized tartar, which became almost quite neglected. But M. Saignette, a physician of Rochelle, who was the first inventor and vender of this salt, did not publish the preparation of it, which he kept as a secret: and this probably contributed not a little to the great esteem which this medicine had acquired; for men are naturally inclined to put a much greater value on secrets, than on what is universally known. He gave it the name of *Sal Polychrestum* and the public called it also *Saignette's Salt*, and *Rochelle Salt*. Since the discoveries of M. Geoffroy and M. Boulduc were published, the method of preparing this salt hath been no secret: it was described in dispensatories, and every apothecary hath made it ever since.

Saignette's salt, as well as every other soluble tartar, melts when laid on live coals, boils up, emits smoke, and leaves a black charred matter behind. This resemblance of Saignette's salt to tartarized tartar, joined to the smell of the vapour which exhaled in burning it, and is the same with that of tartar, were the first notices that led M. Boulduc to suppose this salt to be a soluble tartar. On examining the alkaline coal produced by the calcination, and comparing it with that left by tartarized tartar, he perceived there was some difference between them. At last his friend, M. Groffe, having advised him, as he tells us in his memoir, to combine crystal of tartar with the salt of soda, and to examine the new salt that would result

* It could not be any longer concealed; for M. Geoffroy having made some experiments on the same subject, without knowing any thing of what M. Boulduc had done, likewise discovered it. See the history of the academy for 1731, p. 35.

from their union, M. Boulduc immediately suspected that it must produce a species of soluble tartar, which might possibly prove to be the salt in question. Nor was he mistaken in his conjecture: for with these two saline substances he actually composed a salt perfectly like Saignette's.

Under the head of borax we remarked that it contains an alkali like the basis of sea-salt. This alkali is not perfectly neutralized by the sedative salt, which is also contained in borax: for its alkaline properties are so perceptible as to have led some chymists to think that borax was only an alkali of a particular kind. This induced M. le Fevre, a physician at Uzes, and one of the academy's correspondents, to combine crystal of tartar with borax, and to examine the result. He communicated to the academy his experiments on this subjects; by which he found that the combination of these two saline matters forms a soluble tartar, but greatly different from Saignette's salt; especially in that it doth not crystallize, but remains in the form of a gummy matter, and retains all the acidity natural to pure cream or crystal of tartar: a circumstance which is very remarkable.

Mr. Lemery had the curiosity to repeat M. le Fevre's experiment, and found that this singular soluble tartar had the properties ascribed to it by the inventor. The process he recommends for making the experiment with success is as follows:

“ Take four ounces of crystal of tartar finely
“ pulverized, and two ounces of borax carefully
“ powdered, and put these two salts into a flint-
“ glass body. Pour on them two ounces of water,
“ and set the cucurbite in a sand-bath. Warm it
“ with a gentle fire, and then increase the heat so
“ as to make the liquor boil for a quarter of an
“ hour; which will produce a perfect dissolution
“ of the cream of tartar and borax. After the
“ dissolution of these two salts united together, the
“ liquor

“ liquor will remain clear and limpid, though the
 “ boiling hath dissipated a good deal of it. If the
 “ liquor be still further evaporated, the remainder
 “ will have the consistence of honey, or turpen-
 “ tine : and, if the evaporation be carried still
 “ farther, with a gentle heat, the matter remain-
 “ ing will in colour resemble the gum of a plumb-
 “ tree, and yield to pressure as that does ; and, if
 “ it be exposed to the air in a damp place, it will
 “ grow moist and run, almost like salt of tartar :”
 a new and singular property which belongs neither
 to borax nor to crystal of tartar, when they are
 not combined together.

All soluble tartars are easily decomposed, by
 means of a certain degree of heat. They yield in
 distillation the same principles as tartar ; and the
 alkali that remains, when they are perfectly cal-
 cined, consists of that which the tartar naturally
 affords, and of the alkaline matter with which it
 was converted into a neutral.

These neutral salts, resulting from the union of
 crystal of tartar with any alkaline matter, are also
 decomposed by all the acids, even by vinegar,
 which nevertheless is an oily vegetable acid, and
 consequently of the same kind with crystal of tar-
 tar. The reason of this is that the acid of vine-
 gar, though blunted by much phlegm and oil, must
 be considered as a free and pure acid, when com-
 pared with crystal of tartar ; which is still more em-
 barassed with heterogeneous matters, so as to be a
 semi-neutral salt.

When soluble tartar is decomposed by an a-
 cid, the crystal of tartar, which helped to consti-
 tute the neutral salt, is then wholly recovered.
 This saline matter, being separated from that which
 rendered it soluble in water, ceases now to be so
 and for that reason precipitates to the bottom of
 the liquor.

The neutral salts, resulting from the decomposi-
 tion

tion of soluble tartar by an acid, differ according to the acid made use of. From Saignette's salt decomposed by the vitriolic acid Mr. Boulduc obtained a true Glauber's salt, and a precipitate of crystal of tartar : and this he justly adduces as a demonstrative proof, that Saignette's salt is no other than crystal of tartar neutralized by a fixed alkali analogous to the basis of sea-salt.

Though all soluble tartars may be decomposed by acids, as hath just been said, yet they do not all forsake their bases with equal facility. Mess. Duhamel and Groffe found that, in this respect, they observe the following order, beginning with those which afford the readiest and most copious precipitate : viz. soluble tartar made 1. with potash ; 2. with chalk ; 3. with uncalcined oyster-shells ; 4. with stone-lime ; 5. with calcined oyster-shells ; 6. with salt of tartar ; 7. with salt of soda ; 8. and lastly, tartar made soluble with borax is not precipitated by distilled vinegar.

It is not easy to account for this difference between soluble tartars. If the salt of soda were more alkaline than salt of tartar, and borax more alkaline than the salt of soda, it might be conjectured that the more alkaline the matters are with which crystal of tartar is neutralized, the closer is the union it contracts with them ; since it is plain, from what hath been said on this subject, that though soluble tartars, which have for their basis absorbent earths only, not converted into lime, are more easily decomposed than those which are rendered soluble by limes ; and these again more easily than those which have a fixed alkali for their basis. But, on the contrary, the salt of soda is less alkaline than salt of tartar, and borax still less than the salt of soda.

PROCESS III.

Crystal of Tartar combined with Iron. Chalybeated Tartar. Tincture of Steel with Tartar. Soluble Chalybeated Tartar.

MIX four ounces of iron, in filings, with one pound of white tartar finely pulverized. Boil the mixture in about twelve times as much water as you took of tartar. When the saline part of the tartar is dissolved, filter the liquor boiling-hot through a flannel bag, and then set it in a cool place. In a very little time crystals of a ruffet colour will shoot therein. Decant the liquor from these crystals; evaporate it to a pellicle, and set it again to crystallize. Go on in this manner till it will shoot no more. Collect all the salt you have thus obtained, and keep it under the name of *Chalybeated Tartar*.

To make the tincture of steel with tartar, mix together six ounces of clean iron filings, and one pound of white tartar in powder. Put this mixture into a large iron kettle, and pour thereon as much rain-water as will moisten it. Make a paste of this matter, and leave it thus in a mass for twenty-four hours. Then pour on it twelve pounds of rain-water, and boil the whole for twelve hours at least, stirring the mixture frequently, and adding from time to time some hot water, to supply the place of what evaporates. When you have thus boiled the liquor, let it stand quiet for some time, and then pour it off from the sediment at bottom. Filter, and evaporate to the consistence of a syrup; and you have the *tincture of Mars with tartar*. The dispensatories generally order an ounce of rectified spirit of wine to be poured on this tincture, in order

der to preserve it, and to keep it from growing mouldy, as it is very apt to do.

Soluble chalybeated tartar is prepared by mixing four ounces of tartarized tartar, with one pound of the tincture of Mars with tartar, and evaporating them together in an iron vessel to dryness; after which it is kept in a well stopped phial, to prevent its growing moist in the air.

OBSERVATIONS.

The three preparations of this process are medicines very well known and much used. There is even reason to think that those, who first thought of combining tartar in this manner with iron, had it in their view to prepare compositions useful in medicine, rather than merely to produce new combinations for the improvement of chymistry.. Indeed, were we to consider only the account here given of the manner in which these three compositions are made, we should be inclined to think crystal of tartar incapable of dissolving iron so thoroughly and radically, that, from the union of these two substances, a neutral metallic salt should arise, a tartar neutralized and made soluble by iron. For it is very certain that the first of these preparations, which is called chalybeated tartar, is nothing but the saline part of tartar dissolved by boiling water, and then precipitated and crystalized along with particles of iron, that are reduced, at most, into a rust, or a crocus only, but have contracted no union with the crystal of tartar, which remains as acid and as indissoluble after this preparation as before. According it is called only *chalybeated tartar*, and not *soluble chalybeated tartar*: and, as this latter name hath been given only to the tartarized tincture of Mars compounded with tartarized tartar; that is with tartar rendered soluble by a fixed alkali, and not by iron; there is reason

reason to presume, that the tincture of mars alone was not thought worthy of being called a soluble chalybeated tartar; but that the name, importing *tartar rendered soluble by mars*, belonging to that tincture only when compounded with a true soluble tartar.

It is nevertheless very certain that the tincture of mars made with tartar contains a true soluble chalybeated tartar; that is. a neutral salt consisting of crystal of tartar united with iron, and rendered soluble by that union. The long boiling, necessary to prepare this tincture, gives the acid of tartar time to dissolve the iron radically, and to unite very closely therewith: but this is not the case in the preparation of chalybeated tartar; to make which the tartar is boiled in water only as long as is necessary for the dissolution of its saline parts; that is, about a quarter or half an hour; in which space the acid of the tartar can scarce begin to act on the surface of the iron; for acids have not so quick an effect on metals, as on alkalis and absorbent earths. Metallic substances, being vastly more compact, are not near so soon dissolved by acids, and especially by vegetable acids weakened with heterogeneous matters, as the acid of tartar is.

I thought the dissolution of iron by tartar a point of sufficient importance to deserve a little more attention than hath commonly been given to it; and for that reason resolved to examine, and trace with care, the phænomena observable in this operation,

As the crude tartar employed in making the tartarized tincture of mars, is replete with many oily and earthy parts, which cannot but obstruct the dissolution of the iron, and prevent our seeing clearly how that dissolution is carried on, I thought it better to make use of cream, or crystals, of tartar, which, being pure and freed from all those heterogeneous

heterogeneous parts, dissolve in boiling water without prejudicing its transparency.

I therefore pulverized cream of tartar, and dissolved as much thereof in boiling water as it would take up. This solution I poured boiling hot into a matrafs, at the bottom of which I had laid some fine iron wire cut into small pieces. I set the matrafs in a sand-bath; and having heated it so as to make the liquor boil, I observed that, the instant before it boiled, the liquor began to act very perceptibly upon the iron, in the same manner as other acids act upon metallic substances; that is, there appeared on the surfaces of the little bits of iron small bubbles, which immediately rose to the surface of the liquor, and succeeded each other so fast, that they formed lines, or jets, seemingly continued from the surface of the iron to the surface of the liquor, which little by little acquired a faint tinge of yellow.

When the liquor was heated so as to boil, the dissolution still went on, but much more briskly, and the liquor acquired a deeper colour. After boiling about an hour, the liquor, which at first was very clear, became turbid, and of an opaque white; which made me think that some of the cream of tartar, dissolved therein, began to precipitate.

I let the whole boil some time longer, and the white precipitate becoming more considerable, I resolved to filter the liquor, which passed through clear, and tinged with a greenish yellow. There remained on the filter a whitish sediment, which I found to be true cream of tartar. The filtered liquor tasted much like a solution of copperas. I evaporated it in a glass basin, set it in a sand-heat, but no pellicle appeared; which made me conclude that it would produce no crystals: accordingly having taken some of it out of the basin,

when it was considerably reduced by evaporation, and set it in a cool place, no crystal shot in it.

The rest of the liquor I evaporated to dryness: it left a blackish brown residuum, which had the same taste with the liquor before evaporation, but much stronger. This residuum melts very readily in the mouth, without leaving on the tongue the least gritty particle. Being exposed very dry to the air, it grows moist, and runs into a liquor in a very little time. It dissolves easily and readily in a very small quantity of cold water. This solution being mixed with fixed alkalis, in various proportions, doth not grow turbid, nor drops any precipitate; but with a decoction of galls it makes ink. Acids give it a much clearer colour, and at first produce no precipitation; but, in a quarter of an hour, there appears a precipitate much of the same colour with the solution. This precipitate is no other than cream of tartar, tinged of a russet colour by the liquor, which grows turbid, and a little whitish, when the precipitate begins to form.

These experiments, and the circumstances attending them, will not allow us to doubt the truth of what I advanced concerning the tincture of mars made with tartar, viz. that it is nothing but crystal of tartar by which iron is dissolved, and which is rendered soluble by that metal. We see at the very first that crystal of tartar acts upon iron, just as other acids do. Indeed this metallic solution is not precipitated by alkalis; but we know that alkalis possess the property of dissolving iron, especially when the metal is previously divided by an acid; so that there is reason to think this may be the case, when an alkali is mixed with our soluble chalybeated tartar.

As this soluble tartar is a saponaceous and oily salt, it is also possible that it may be dissolved entirely by the alkali, without suffering any decomposition: especially as alkalis decompose neutral metallic

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lic salts by means only of the stronger affinity which they have with the acids, than with the metals of which those salts are compounded. Now, as our soluble chalybeated tartar is compounded of that metal which the alkali dissolves with the greatest ease, and of that acid with which it hath the least affinity of any, it is very possible that it may not have a greater affinity with the acid than with the metallic basis of this salt, and so be incapable of decomposing it. However, as this soluble chalybeated tartar makes a black liquor with a decoction of galls, and as nothing but iron dissolved by an acid hath that property, it may be safely concluded that this salt really consists of iron dissolved by the acid of tartar.

The precipitate which a solution of this salt lets fall, on the addition of an acid, is another proof that it consists of these two principles: for this precipitate can be no other than the tartarous acid, which, being the weakest of all acids, is separated from the iron by the acid added to the solution; which acid unites with the martial basis, and forms another neutral metallic salt, according to the acid employed. Lastly, the great solubility of the defecated residuum of the tincture of mars, made with tartar, is a very strong and decisive proof, that this residuum is no other than iron dissolved by the acid of tartar: for what else can it be? Nothing but iron and crystal of tartar is made use of in the operation; and neither of these two substances singly is so soluble as this new body.

We know moreover, that crystal of tartar, which itself is indissoluble, forms a soluble tartar when combined with pure absorbent earths, though these matters be still more indissoluble than it, or rather, are not soluble at all. Hence it is very natural to conclude that our residuum is a tartar rendered soluble by iron. This chalybeated tartar is even more soluble than any other sort of soluble tartar; for it very readily grows moist in the air, and runs wholly into a liquid; on which account it is not susceptible of crystallization.

I return to one of the circumstances attending my experiment, which it is proper I should account for; though I have hitherto only mentioned it, without more particular notice, that I might not break the connection between facts and the consequences resulting from them. The circumstance I mean is the precipitation of the cream of tartar dissolved in the liquor, which, I said, happens when the saline solution hath boiled upon the iron about an hour. This precipitation of the cream of tartar may be partly occasioned by the evaporation of the water in which it is dissolved: for the water having taken up, as was said, as much cream of tartar as it was capable of dissolving, when the quantity of water comes to be lessened, a proportional quantity of cream of tartar must precipitate.

But some other cause must also contribute to produce this precipitation: for, as I boiled my liquor in a matrafs, the evaporation of the liquor could not be considerable, and yet the precipitate was very copious. Moreover, I replenished the matrafs with much more water than was necessary to replace what had evaporated; yet I could not redissolve the precipitated cream of tartar, nor even sensibly lessens its quantity.

The true cause of this effect I take to be as follows. When the solution of cream of tartar hath boiled for some time upon the iron, and dissolved a certain quantity thereof, a proportional quantity of soluble chalybeated tartar is formed. Now as this salt is much more soluble in water than cream of tartar, and as water always takes up the more soluble salts, preferably to the less soluble, it is not surprising that cream of tartar, being one of those saline substances which dissolve with the greatest difficulty, should on this occasion separate from the liquor and precipitate; yielding its place to a salt which hath a much greater affinity with water.

Hence it appears that to re-dissolve the cream of tartar

tartar, and render it capable of continuing to dissolve the iron as efficaciously as before, it is not sufficient that fresh water be added; but the solution of the soluble chalybeated tartar already formed must be entirely decanted, and fresh water poured on the residue; and then this water, not being impregnated with any soluble chalybeated tartar, will be capable of re-dissolving the cream of tartar, and every thing will go on as at the beginning of the operation, till the cream of tartar come to precipitate again, for the same reason as before, and make a repetition of the same management necessary. The liquor is far from being saturated with soluble chalybeated tartar, when the precipitation of the cream of tartar renders it necessary to decant it; so that the water must be often renewed, if you carry the operation to the utmost; and then all these solutions must be added together, and evaporated, either to dryness, if you desire to have the salt in a dry form, or to any other degree you think proper.

This method I followed at first, but as it is exceeding long and tedious, though perhaps the best; and as I wanted to have a moderate quantity of soluble chalybeated tartar, with less trouble, and in less time, if possible, I resolved to try whether or no the cream of tartar, though separated from the liquor and undissolved, were still capable of acting on the iron with such efficacy as to dissolve it. I therefore continued to boil the tartarous solution on the filings of iron, notwithstanding the precipitation of the cream of tartar, taking care only to add fresh water from time to time, as directed in the process for the tartarized tincture of mars, to replace what evaporated; and I observed that, in fact, the cream of tartar, though not perfectly dissolved, but only divided and agitated by the motion of boiling, still continued to act upon the iron; so that the liquor, after boiling seven or eight hours, was so impreg-

nated as to yield by evaporation a reasonable quantity, in bulk, of salt in a dry form.

P R O C E S S IV.

Crystal of Tartar combined with the reguline part of Antimony. Stibiated or Emetic Tartar.

PULVERIZE and mix together equal parts of the glass and of the liver of antimony. Put this mixture, with the same quantity of pulverized cream of tartar, into a vessel capable of containing as much water as will dissolve the cream of tartar. Boil the whole for twelve hours, from time to time adding warm water, to replace what is dissipated by evaporation. Having thus boiled your liquor; filter it while boiling hot; evaporate to dryness; and you will have a saline matter which is *emetic tartar*.

O B S E R V A T I O N S.

The glass and liver of antimony are no other, as was said in its place, than the metallic earth of antimony separated from the redundant sulphur of that mineral; but still retaining such a quantity of phlogiston as to possess, excepting its metalline colour, nearly the same properties with regulus of antimony, and especially its emetic quality, and its solubility in acids. Indeed these two preparations seem to have more of an emetic quality, than the regulus itself, and therefore are employed preferably to all others in the preparation of emetic tartar.

It is not yet ascertained in which of the principles of antimony its emetic virtue resides. We are sure however that it cannot be ascribed to its earthy part: for the calx of antimony, when entirely deprived

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prived of all phlogiston, is not emetic, nor even purgative; as is evident from the effects of diaphoretic antimony and the pearly matter.

Some authors think antimony contains an arsenical principle, to which they impute its emetic quality; nor is their opinion altogether void of probability. For this arsenical part seems to be indicated by several of the properties of antimony, and particularly by its affinities with other metallic substances, in which it very nearly resembles arsenic. But this doth not amount to a positive proof: for we can draw nothing but probable conjectures, at most, from such analogies.

Other chymists think the emetic virtue of antimony depends on the union of its metallic earth with its phlogiston. This opinion seems to me much more probable than the other: for by only recombining a phlogiston with the earth of antimony, deprived by calcination of all its emetic virtue, that virtue is perfectly restored, and the regulus thus revived is no less emetic than that which never underwent calcination.

However this be, it is certain that cream of tartar acquires an emetic quality, not by barely uniting with one of the principles of antimony, but by dissolving entirely the reguline or semi-reguline part thereof; and that its emetic quality is so much the stronger, the more of that substance it hath dissolved. This is the result of several experiments made on the subject by Mr. Geoffroy.

That gentleman collected several parcels of emetic tartar, having different degrees of strength. "I employed, says * he, an ounce of each of those emetic tartars: I rubbed them separately with an equal weight, or something more, of a black flux, made of two parts of red tartar and one part of nitre calcined together. These mixtures

* Memoirs of the Academy for 1734, p. 421.

" I put

“ I put into different crucibles, formed like inverted
 “ cones: I kept them in a melting heat till
 “ the salts in fusion sunk, and appeared like a
 “ smooth oil at the bottom of each crucible. I
 “ then let the fire go out, broke the crucibles
 “ when cold, and found the resuscitated regulus in
 “ a mass at bottom.

“ Out of one ounce of the weakest emetic tar-
 “ tars I obtained from thirty grains to one dram
 “ eighteen grains of regulus. From one ounce
 “ of such as were of a middling strength I got one
 “ dram and an half; and the most violent yielded
 “ me two drams and ten grains.

“ The power therefore of the strongest emetic
 “ tartars, continues he, depends on the quantity
 “ of regulus of antimony dissolved by the cream
 “ of tartar, and the nearer the preparations of
 “ antimony, on which the solution of cream of
 “ tartar is boiled, are to the form of a regulus or
 “ a glass, the more violent is the emetic tartar;
 “ because the vegetable acid of the tartar acts then
 “ more immediately upon the emetic part of the
 “ antimony, and dissolves more of it.”

Mr. Geoffroy found upon trial that cream of
 tartar boiled for a due time on crude antimony,
 doth indeed dissolve a little of the reguline part
 thereof; but that the quantity of regulus dissolved
 thereby is so very small, that the emetic tartar pro-
 duced is extremely weak. The gross sulphur, in
 this case, hinders the cream of tartar from acting
 on the reguline part with so much efficacy, as when
 the antimony is properly prepared by freeing it
 entirely from its redundant sulphur.

Nothing can be added to what Mr. Geoffroy hath
 said on this subject. His experiments are decisive,
 and set the truth he intended to prove in the clear-
 est light.

Mr. Hoffman affirms that emetic tartar loses
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part of its virtue by being boiled too long. A very able chymist goes so far as to say that tartar ought not to boil above six or seven minutes with prepared antimony; because longer boiling destroys part of its emetic quality. Can this arise from hence that cream of tartar, after dissolving a certain quantity of the reguline substance, separates from it afterwards? Or is the cream of tartar itself decomposed by too long boiling? This deserves to be particularly enquired into, as well as the nature of the metallic salt, which results from the union of the acid of tartar with the regulus of antimony.

Crystal of tartar acts also on several other metallic substances, and particularly on lead; with which it forms a salt, resembling tartarized tartar in the figure of its crystals.



C H A P. V,

OF THE PRODUCT OF ACETOUS FERMENTATION.

P R O C E S S I.

*Substances susceptible of the Acetous Fermentation
turned into Vinegar.*

THE wine, the cyder, or the malt-liquor, which you intend to convert into vinegar, being first thoroughly mixed with its lees, and with the tartar it may have deposited, put your liquor into a vat used before, either for making or for holding vinegar. This vessel must not be quite full, and the external air must have access to the liquor contained

tained in it. Set it where the air may have a degree of warmth answering nearly to the twentieth degree above 0 in Mr. de Réaumur's thermometer. Stir the liquor from time to time. There will arise in it a new fermentative motion, accompanied with heat : its vinous odour will gradually change, and turn to a sour smell, which will become stronger and stronger, till the fermentation be finished, and cease of itself. Then stop your vessel close ; the liquor it contains will be found converted into vinegar.

OBSERVATIONS.

All substances that have undergone the spirituous fermentation are capable of being changed into an acid, by passing through this second fermentation, or this second stage of fermentation. Spirituous liquors, such as wine, cyder, beer, being exposed to a hot air, grow sour in a very short time. Nay, these liquors, though kept with all possible care, in very close vessels, and in a cool place, degenerate at last, change their natures, and insensibly turn sour. Thus the product of spirituous fermentation naturally and spontaneously degenerates to an acid.

For this reason it is of great importance, in making wine, or any other vinous liquor, to stop the fermentation entirely, if you desire the wine should contain as much spirit as possible. It is even more advantageous to check the fermentation, a little before it comes to the height, than afterwards : because the fermentation, though slackened, and in appearance totally ceased, still continues in the vessels ; but in a manner so much the less perceptible, as it proceeds more slowly. Thus those liquors, in which the fermentation is not quite finished, but checked, continue for some time to gain more spirit ; whereas, on the contrary, they degenerate and

and gradually turn sour, if you let the spirituous fermentation go on till it be entirely finished.

The production of the second fermentation, which we are now to consider, is an acid of so much the greater strength, the stronger and more generous the spirituous liquor, in which it is excited, originally was. The strength of this acid, commonly called *vinegar*, depends likewise in a great measure on the methods used in fermenting the vinous liquor, in order to convert it into vinegar: for if it be fermented in broad, flat vessels, and left to grow sour of itself, the spirituous parts will be dissipated, and the liquor, though sour indeed, will be vapid and effete.

The vinegar-makers, to increase the strength of their vinegar, use certain methods of which they make a mystery, keeping them very secret. However, Mr. Boerhaave gives us, from some authors, the following description of a process for making vinegar.

“ Take two large oaken vats or hogheads, and
“ in each of these place a wooden grate or hurdle,
“ at the distance of a foot from the bottom. Set
“ the vessel upright, and on the grates place a moderately close layer of green twigs, or fresh cuttings of the vine. Then fill up the vessel with
“ the foot stalks of grapes, commonly called the
“ *rape*, to within a foot of the top of the vessel,
“ which must be left quite open.

“ Having thus prepared the two vessels, pour
“ into them the wine to be converted into vinegar,
“ so as to fill one of them quite up, and the other
“ but half full. Leave them thus for twenty-four
“ hours, and then fill up the half-filled vessel, with
“ liquor from that which is quite full, and which
“ will now in its turn be left only half full. Four
“ and twenty hours afterwards repeat the same operation, and thus go on, keeping the vessels
alternately

“ alternately full and half full, during every twen-
“ ty four hours, till the vinegar be made. On the
“ second or third day there will arise, in the half-
“ filled vessel, a fermentative motion, accompanied
“ with a sensible heat, which will gradually in-
“ crease from day to day. On the contrary, the
“ fermenting motion is almost imperceptible in
“ the full vessel; and as the two vessels are alter-
“ nately full and half full, the fermentation is by
“ that means, in some measure, interrupted, and
“ is only renewed every other day, in each vessel.
“ When this motion appears to be entirely ceas-
“ ed, even in the half filled vessel, it is a sign that
“ the fermentation is finished; and therefore the
“ vinegar is then to be put into common casks
“ close stopped, and kept in a cool place.

“ A greater or less degree of warmth accelerates
“ or checks this, as well as the spirituous fermenta-
“ tion. In France it is finished in about fifteen
“ days, during the summer; but if the heat of
“ the air be very great, and exceed the twenty
“ fifth degree of Mr. de Réaumur's thermometer,
“ the half filled vessel must be filled up every
“ twelve hours; because if the fermentation be
“ not so checked in that time, it will become so
“ violent, and the liquor will be so heated, that
“ many of the spirituous parts, on which the
“ strength of the vinegar depends, will be dissipat-
“ ed; so that nothing will remain, after the fer-
“ mentation, but a vapid wash, sour indeed, but
“ effete. The better to prevent the dissipation of
“ the spirituous parts, it is a proper and usual pre-
“ caution to close the mouth of the half-filled ves-
“ sel, in which the liquor ferments, with a cover
“ made also of oak wood. As to the full vessel,
“ it is always left open, that the air may act free-
“ ly on the liquor it contains: for it is not liable

“ to the same inconveniences, because it ferments
“ but very slowly.”

The vine-cuttings and grape stalks, which the vinegar-makers put into their vessels, serve to increase the strength of the liquor. These matters contain a very manifest and perceptible acid. They also serve as a ferment; that is, they dispose the wine to become eager more expeditiously and more vigorously. They are the better, and the more efficacious, for having been once used, because they are thereby thoroughly drenched with the fermented acid: and therefore the vinegar-makers lay them by, for preparing other vinegar, after washing them nimbly in running water, in order to free them from a viscid oily matter, which settles on them during the fermentation. This matter must by all means be removed; because it is disposed to grow mouldy and rot; so that it cannot but be prejudicial to any liquor into which you put it.

As the acetous fermentation differs from the spirituous in its production, so it doth in many circumstances attending it. 1. Motion and agitation are not prejudicial to the acetous fermentation, as they are to the spirituous; on the contrary, moderate stirring, provided it be not continual, is of service to it. 2. This fermentation is accompanied with remarkable heat; whereas the warmth of the spirituous fermentation is scarce sensible. 3. I do not believe there ever was an instance of the vapour that rises from a liquor in acetous fermentation proving noxious, and producing either disorders or sudden death, as the vapour of fermenting wine doth. 4. Vinegar deposits a viscid oily matter, as hath just been observed, very different from the lees and tartar of wine. Vinegar never deposits any tartar; even though new wine, that hath not yet deposited its tartar, should be used in making it.

The following processes will give us occasion to treat of the nature of vinegar, and the principles of which it consists.

PROCESS II.

To concentrate Vinegar by Frost.

EXPOSE to the air, in frosty weather, the vinegar you desire to concentrate. Icicles will form in it; but the whole liquor will not freeze. Take out those icicles: and if you desire a further concentration of your vinegar by this method, the liquor which did not freeze the first time must be exposed to a stronger frost. More icicles will form therein, which must likewise be separated, and kept by themselves. The liquor which doth not freeze this second time will be a very strong concentrated vinegar.

OBSERVATIONS.

Liquors, replete with an acid, freeze with much more difficulty than pure water. Thus, if a very aqueous acid liquor be exposed to frost, some of the water in the liquor will presently freeze; while the rest, being rendered more acid by the separation of the frozen phlegm, will remain fluid, and resist the degree of cold which freezes water. Now vinegar, being an acid liquor containing much water, may therefore be highly concentrated by freezing its phlegm in this manner; and the more icicles you get from it, the stronger and more active will the remaining vinegar be.

Mr. Stahl was the first, I believe, who thus made use of congelation, for procuring a very strong

strong acid of vinegar. Mr. Geoffroy hath since taken the same method. A curious and circumstantial account of his experiments, on this subject, are printed in the memoirs of the academy for 1739.

As it was excessive cold in the winter of that year, Mr. Geoffroy took the opportunity of exposing to the frost several vinegars of different strengths; and he determined the degree of acidity in each, both before and after their concentration, in order to compare them, and discover how much stronger each vinegar was rendered by the freezing of the aqueous part. To determine the strength of the vinegars, he made use of the method pointed out by Mr. Homberg and Mr. Stahl. This method consists in combining to the exact point of saturation, a certain quantity of vinegar with well dried salt of tartar. The more salt of tartar is required, to absorb and perfectly neutralize the vinegar, the stronger it must be reckoned; because the quantity of alkali necessary to constitute a neutral salt is always proportioned to the quantity of acid in that salt.

One of the vinegars employed in Mr. Geoffroy's experiments, two drams of which were entirely absorbed by six grains of salt of tartar, having been concentrated by once freezing, and thereby reduced from eighteen quarts to six, he found it so increased in strength, that two drams thereof required twenty four grains of salt of tartar to absorb them.

The first icicles that separate from vinegar, in this process, are perfectly clear, and as insipid as water. As the vinegar becomes more concentrated, the plates of ice becoming thinner, more spongy, and flaky like snow, retain between them some portion of the acid; and it is proper to begin to save them as soon as they appear to be sensibly acid.

Mr. Geoffroy carried the concentration of vinegar as far as the cold of that winter 1739 would allow

allow him; and eight quarts of vinegar, already concentrated by vinegar in the preceding years, being reduced to two quarts and a half by the frost, of the 19th of January, the coldest day of that year, was found to be so strong, that two drams thereof required forty-eight grains of salt of tartar to absorb them. The icicles of this vinegar, being thawed, retained so much strength as to require thirteen grains of the salt of tartar to absorb them.

Vinegar suffers no decomposition by the congelation of its phlegm, and the consequent concentration of its acid. What is left still contains all the principles of which vinegar consists. Its principles are only brought nearer together, and into a smaller compass: and for this reason it grows the thicker, the more it is concentrated. When therefore you desire to concentrate the acid of vinegar, and at the same time to purify it, that is, to free it from some of its oil and earth, you must have recourse to distillation.

Wine, as well as vinegar, may be concentrated by freezing. Mr. Stahl exposed several sorts of wine to the frost, and by that means separated from them about two thirds, or three quarters, of almost pure phlegm. The remainders of the wines so concentrated were of a somewhat thicker consistence. They were very strong, and kept for several years without altering in places where the free access of the air, alternately cold and hot according to the seasons, would have soured, or spoiled, any other kind of wine in the space of a few weeks.

Wine thus concentrated by freezing is not thereby decomposed, any more than vinegar: it is only dephlegmated. By the addition of as much water as was separated from it, you may restore it to its former condition; in which respect it differs greatly from the residue of wine whose spirituous part, with a proportion of its phlegm, hath been drawn off

off by distillation: for though you mix that residue again with the principles you separated from it, you can never make wine of it again; the spirituous part being no longer in a capacity to combine with the other principles of the wine, in the same manner as before that separation. And this shews that heat, besides separating the most volatile parts, produces moreover a considerable change in the disposition of those which did not rise in the first distillation.

Since the above experiments were made by Mess. Stahl and Geoffroy, concentration by freezing is pretty frequently practised in laboratories; but on vinegar only, seldom on wine; because, when vinegar is thus concentrated, a much stronger acid is more easily and more expeditiously obtained from it, as will be shewn in the following process; whereas the distillation, as well as the quality, of spirit of wine is much the same, whether the wine it is obtained from be concentrated or no. The reason of this difference is, that spirit of wine, being very light, rises in distillation before the phlegm; whereas the acid of vinegar, being much more ponderous, rises only at the same time with the aqueous part, or even after it.

P R O C E S S III.

Vinegar analyzed by Distillation.

INTO a glass or stone cucurbit put the vinegar to be distilled; fit to it a glass head; place your alembic in the sand bath of a distilling furnace, and unite on a receiver. Apply a very gentle heat at first. A clear, limpid, light liquor will rise, and fall in distinct drops, like water, from the nose of the alembic.

Continue distilling this first liquor, till the vinegar

gar contained in the cucurbit be diminished about a fourth part. Then shift your receiver, and increase the fire a little. A clear liquor will still come over, but heavier and more acid than the former. Distill in this manner, till you have drawn off, into your second receiver, two thirds of the liquor that was left in the cucurbit.

A thick matter will now remain at the bottom of the still: put it into a retort; lute on a receiver, set your retort in a reverberating furnace, and distill with degrees of fire. There will come over a limpid liquor, very acid and sharp, yet ponderous, and requiring a great degree of fire to raise it: on which account it makes the receiver very hot. It hath a strong empyreumatic smell. When the distillation begins to slacken, increase your fire. There will rise an oil of a fetid, quick smell. At last, when nothing more will rise with the strongest fire, break the retort, and in it you will find a black charred matter: burn it, and from the ashes lixiviated with water you will obtain a fixed alkali.

OBSERVATIONS.

None of the liquors that come over in this operation, before the last fetid oil; seem to have any other properties than those of an oily acid; none of them is inflammable, none of them resembles spirit of wine; but all of them being thrown into the fire extinguish it. Mr. Boerhaave however takes notice that a chymist, named Vigani, affirms the first portion of the liquor which rises in the distillation of vinegar to be inflammable, and no other than spirit of wine. Mr. Boerhaave suspected that this might happen from Vigani's having distilled vinegar too newly made; and found upon trial that vinegar, being distilled soon after it was made, yielded at first in distillation a certain quantity of an ardent spirit; but that the same thing did not happen

happen in the distillation of old vinegar. And this proves that fermentation hath the same effect on vinegar as on wine; that is, that though the fermentation which produces these liquors seems to be over in a certain time, when the violent intestine commotion ceases, yet it still continues in the vessels for a considerable time after, though it be imperceptible. Thus, the portion of ardent spirit, obtained from some vinegars, comes from a small quantity of wine, which still remains unchanged in these vinegars, not having had time enough to turn sour. For it is certain, from the experiments of all other chymists as well as Mr. Boerhaave, that vinegar, when old enough, yields no ardent spirit in distillation.

But though old and well made vinegar yields no ardent spirit in distillation, we cannot thence conclude that it contains none. On the contrary, there are experiments which demonstrate that some of the ardent spirit, which was in the wine before it was turned into vinegar, still remains; but probably so combined and blended with the acid part, that it cannot be separated and rendered perceptible but by peculiar processes.

Mr. Geoffroy obtained an ardent spirit from vinegar, by distilling it as soon as it was concentrated by freezing. " This spirit, says he *, is " the first liquor that rises. At first it hath only " the same degree of inflammability as brandy; " but, when re-distilled in the *balneum marie*, it " fires gun-powder, like the best rectified spirit of " wine: with this difference, that our spirit is im- " pregnated with an oil of an acrid taste and em- " pyreumatic smell, which makes it yellow, and " imparts its odour to it. This spirit, at least " that which comes over first, retains none of the " acid of the vinegar; seeing it neither changes the

* Memoirs of the Academy for 1729.

“ the tincture of violets, nor effervesces with salt
“ of tartar.”

Mr. Geoffroy observes, that, if vinegar concentrated by freezing be afterwards kept for several years, no ardent spirit will then be obtained from it by distillation. And this confirms what we said of unconcentrated vinegar, and gives reason to think that the ardent spirit obtained from vinegar, either by distilling it after concentration by freezing, or by other processes of which we shall treat in the sequel, is foreign to the vinegar, and is only found therein, as was said above, because vinegar contains a certain quantity of wine which hath not altered its nature. For the spirit of wine we obtain from vinegar doth not hinder our obtaining from it a great deal of acid, which being more ponderous rises after it. Mr. Geoffroy gives the following account of the sequel of his analysis of vinegar by distillation.

“ Continuing to distill in a *balneum mariæ* the
“ concentrated vinegar, of which I had employed
“ four pounds two ounces, there was left, after the
“ distillation, a residuum of fourteen ounces;
“ which could not rise, because it was too thick.
“ I found it covered with a saline crust, which is
“ the true essential salt of vinegar, and not of the
“ same nature with tartar; for tartar of wine is
“ scentless; whereas the salt of vinegar hath a
“ pungent smell, being the acid of tartar subtili-
“ zed by its union with the sulphureous parts.
“ If a sand-bath be now used, instead of the *balne-*
“ *um mariæ*, to carry on the distillation without
“ burning the matter, part of this salt will be re-
“ solved, and yield the last acid spirit, which is the
“ strongest that can be obtained.

“ After I had, by a sand-heat, extracted all the
“ acid spirit that the several residuums put toge-
“ ther would yield, I found at the bottom of the
“ cucurbit a brown mass, of the consistence of a

“ pretty

“ pretty solid extract. Of this I put into a retort
“ two pounds, together with six pounds of sand
“ well washed and very dry; and, applying a gra-
“ duated heat, I first obtained six ounces of an
“ acid spirit, that smelt very strong of the empy-
“ reuma, and was a little coloured with some por-
“ tion of oil: seven ounces of spirit, having a vo-
“ latile urinous smell, came over next: at last the
“ white vapours appeared more and more dense.
“ A volatile concrete salt adhered to the sides of
“ the ballon, and I found four ounces of a thick
“ fetid oil floating on the spirit. The concrete
“ volatile salt, when collected, weighed two drams.
“ The black matter remaining in the bottom of
“ the retort, being calcined and lixiviated, yield-
“ ed a fat alkaline salt, which it is almost impossi-
“ ble to dry.”

I have given this account of Mr. Geoffroy's analysis of vinegar at length, only because it differs in several respects from that described in the process, which is Mr. Boerhaave's, as well as from those delivered by several other authors, who make no mention either of the saline matter, which Mr. Geoffroy found on the residuum of vinegar, after its first distillation in the *balneum mariæ*, or of the volatile urinous spirit and salt, which he obtained from that residuum.

These differences may arise either from the manner of distilling the vinegar, or from Mr. Geoffroy's vinegar having been concentrated by freezing, or rather from the quantity, and, above all, from the age of the vinegar, examined by those different chymists.

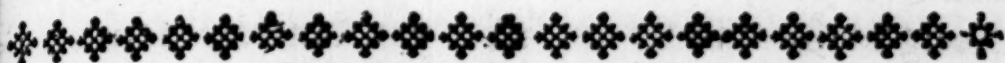
The distillation of vinegar serves not only to separate its acid from a considerable quantity of earth and oily parts, with which it is entangled, but also to dephlegmate and concentrate it. Yet Mr. Lemeris affirms that vinegar is not distilled with a view to dephlegmate it. He condemns the com-
mon

mon method of throwing away the first runnings as useless phlegm, and saving only what comes off afterwards; having, he says, observed, that the phlegm of vinegar cannot be abstracted, like that of many other acid liquors, and that what comes over first is almost as sharp as what rises afterwards, be the fire applied at first ever so small.

There is reason to think that Mr. Lemerier did not carefully enough examine the strength of his spirit of vinegar, at the different stages of his distillation: for Mr. Geoffroy, in the memoir above cited, gives an account of a distillation of vinegar, the product whereof he examined with care, having for that purpose divided it into five different portions: and his experiments put it beyond all doubt, that the first portions of spirit of vinegar are far from being so acid as the last. This vinegar was so strong before distillation, that it required six grains of salt of tartar to absorb two drams of it. Two drams of the first portion of his spirit were absorbed by three grains only of salt of tartar: the acid of the second portion took five grains to absorb it. (Each experiment was made with two drams of vinegar.) The third portion was absorbed by ten grains; the fourth by thirteen, and the fifth took no less than nineteen: which proves that vinegar, like most other acids, may be concentrated by distilling off the most aqueous part, which is lighter than the acid.

There are therefore two ways of concentrating vinegar, and separating its most acid part, namely distillation and congelation. These two methods may be successively applied to the same vinegar, and a very powerful acid obtained by their concurrence. Mr. Geoffroy having exposed to the frost, on the 19th of January 1739, the last ruffet coloured liquor, drawn from the residuum of distilled vinegar, found it so concentrated thereby, that

that it required sixty grains of salt of tartar to absorb two drams of it.



CHAP. VI.

THE ACID OF VINEGAR COMBINED WITH DIFFERENT SUBSTANCES.

PROCESS I.

The Acid of Vinegar combined with alkaline substances. Foliated Salt of Tartar, or Regenerated Tartar. Decomposition of that Salt.

INTO a glass cucurbit put some very pure and well dried salt of tartar; and pour on it some good distilled vinegar, by little and little at a time. An effervescence will arise. Pour on more vinegar, till you attain the point of saturation. Then fit a head to the cucurbit; set it in a sand bath; and having luted on a receiver, distill with a gentle heat, and very slowly, till nothing remain but a dry matter. On this residuum drop a little of the same vinegar; and if any effervescence appears, add more vinegar till you attain the point of saturation, and distill again as before. If you observe no effervescence, the operation was rightly performed.

OBSERVATIONS.

It is not easy to hit the exact point of saturation in preparing this neutral salt; because the oily parts, with which the acid of vinegar is loaded, hinder it from acting so briskly and readily as it would do, if it were as pure as the mineral acids:
and

and for this reason it often happens, that, when we have nearly attained the point of saturation, the addition of an acid makes no sensible effervescence, though the alkali be not yet entirely saturated; which deceives the operator, and makes him conclude erroneously that he hath attained the true point of saturation.

But he easily perceives his mistake, when, after having separated from this saline compound all its superfluous moisture by distillation, he drops fresh vinegar upon it: for then the salts being more concentrated, and consequently more active, produce an effervescence, which would not have been sensible if this last portion of acid, instead of coming into immediate contact with the dried alkali, could not have mixed therewith till diffused through and in a manner suffocated by, that phlegm from which the acid of the vinegar, before neutralized, was gradually separated by its combining with the alkali; that phlegm keeping in solution both the neutral salt already formed and the alkali not yet saturated. And for this reason it is necessary to try, after the first desiccation of this salt, which is called *regenerated tartar*, whether or no the just point of saturation hath been attained.

It may also happen, that, though the point of saturation was exactly hit at first, this compound salt shall nevertheless, after desiccation, effervesce with fresh vinegar, and therefore not be in a perfectly neutral state at that time. In this case the salt must have been dried by too violent a fire, and partly decomposed by an excess of heat carrying off some of the acid, which doth not adhere very strongly to the alkali. This is one of the reasons why it is necessary that regenerated tartar be desiccated with a very gentle heat.

From what hath been said, concerning the desiccation of this neutral salt, it is plain that the use of it is only to free the salt from the great quantity of

of superfluous moisture wherein it is dissolved : which proves that the acid of vinegar, like all other acids dissolved in much water, is separated from most of this redundant phlegm by being combined with a fixed alkali. And hence we must conclude that the acid of vinegar, contained in regenerated tartar deficcated, is vastly stronger and more concentrated than it was before : and accordingly Mr. Geoffroy, having decomposed this salt, by the means of concentrated oil of vitriol, obtained a spirit of vinegar in white vapours, which was very volatile and very strong, but perhaps somewhat depraved with a taint of the vitriolic acid.

Though the acid of vinegar be freed, by combining with a fixed alkali, from a great quantity of superfluous phlegm, as was shewn above ; yet the oily parts with which it is entangled still cleave to it : these parts are not separated from it by its conversion into a neutral salt, but, without quitting it, combine also with the fixed alkali ; and this gives regenerated tartar a saponaceous quality, and several other peculiar properties.

Regenerated tartar, when dried, is of a brown colour. It is semi-volatile ; melts with a very gentle heat, and then resembles an unctuous liquor ; which indicates its containing an oil : when cast upon live coals, it flames ; and, when distilled with a strong heat, yields an actual oil ; all which evidently proves the existence of that oil.

This salt is soluble in spirit of wine ; a quality which it probably owes also to its oil. It requires about six parts of spirit of wine to dissolve it ; and the dissolution succeeds very well in a matrafs, with the help of a gentle warmth. If the spirit of wine be abstracted from this solution, by distilling with a small fire, the salt remains at the bottom of the cucurbit, in the form of a dry substance composed of leaves lying one upon another ; which hath procured

cured it the name of *terra foliata tartari*, or *foliated salt of tartar*.

It is not absolutely necessary that regenerated tartar be dissolved in spirit of wine to make the foliated salt: for it may be procured in this form, by only evaporating the water in which it is dissolved. But the operation succeeds better with spirit of wine; probably because the success thereof depends on using an exceeding gentle warmth: now spirit of wine evaporates with much less heat than water.

Regenerated tartar may also be crystallized. If you desire to have it in this form, combine the acid with the alkali to the point of saturation; evaporate the liquor slowly to the consistence of a syrup, and let it in a cool place; where it will shoot into clusters of crystals lying one upon another like feathers.

Vinegar perfectly dissolves absorbent matters also, and particularly those of the animal kingdom; such as coral, crabs-eyes, pearls, &c. In order to a dissolution of such matters, you must pulverize them, put them into a matraass, and pour on them spirit of vinegar to the depth of four fingers breadth: an effervescence will arise: when that is over, set the mixture to digest two or three days in a sand bath; then decant the liquor, filter it, and evaporate it to dryness with a very gentle heat. The matter which remains is called *salt of coral, of pearls, of crabs eyes, &c.* according to the substances dissolved. If, instead of evaporating the liquor, a fixed alkali be mixed therewith, the absorbent matter, that was dissolved by the acid, will precipitate in the form of a white powder, which is called the *magistery of coral, of pearls, &c.*

P R O C E S S II.

The Acid of Vinegar combined with Copper. Verdegris. Crystals of Copper. This combination decomposed. Spirit of Verdegris.

INTO a large matrafs put verdegris in powder. Pour on it distilled vinegar to the depth of four fingers breadth. Set the matrafs in a moderate sand-heat, and leave the whole in digestion, shaking it from time to time. The vinegar will acquire a very deep blue-green colour. When the liquor is sufficiently coloured, pour it off by inclination. Put some fresh vinegar into the matrafs; digest as before; and decant the liquor again when it is sufficiently coloured. Proceed in this manner till the vinegar will extract no more colour. There will remain in the matrafs a considerable quantity of undissolved matter. The vinegar thus impregnated with verdegris is called *tincture of copper*.

Mix these several tinctures, and evaporate them with a gentle heat to a pellicle. Then set the liquor in a cool place: in the space of a few days a great many crystals of a most beautiful green colour will shoot therein, and stick to the sides of the vessel. Pour off the liquor from the crystals; evaporate it again to a pellicle, and set it by to crystalize. Continue these evaporations and crystallizations, till no more crystals will shoot in the liquor. These are called *crystals of copper*, and are used in painting. To this combination of the acid of vinegar with copper the painters and dealers have given the title of *distilled verdegris*.

O R S E R V A T I O N S.

Verdegris is prepared at Montpellier. To make it they take very clean plates of copper, which they

they lay, one over another, with husks of grapes between, and after a certain time take them out. Their surfaces are then covered all over with a very beautiful green crust, which is *verdegris*. This *verdegris* is nothing but copper corroded by the acid of tartar, analogous to the acid of vinegar, which abounds in the wines of Languedoc, and especially in the rape, husks, and stones of grapes that have a very austere taste. *Verdegris* is a sort of rust of copper; or copper corroded and opened by the acid of wine, but not yet converted entirely into a neutral salt: for it is not soluble in water, nor does it crystallize. This arises from its not being united with a sufficient quantity of acid. The design of the operation here described is to furnish the *verdegris* with the quantity of acid requisite to make it a true metallic salt; for which purpose distilled vinegar is very fit.

Crystals of copper may be obtained, without employing *verdegris*, by making use of copper itself dissolved by the acid of vinegar, according to the method practised with respect to lead, as shall be shewn hereafter. But *verdegris* is generally used, because it dissolves soonest; it being a copper already half-dissolved by an acid correspondent to that of vinegar.

Crystals of copper are decomposed by the action of fire alone, without any additament; because the acid of vinegar adheres but loosely to copper. In order to decompose this salt and extract its acid, it must be put into a retort, and distilled in a reverberatory furnace with degrees of fire. An insipid phlegm rises first, which is the water retained by the salt in crystallizing. This phlegm is succeeded by an acid liquor, which rises in the form of white vapours that fill the receiver. Towards the end of the distillation the fire must be violently urged, in order to raise the strongest and most fixed acid. At last there remains in the retort a black matter,

matter, which is nothing but copper, that may be reduced by melting it in a crucible with one part of salt-petre and two parts of tartar. A similar acid, but more oily, and in a much smaller quantity, may be obtained from verdegris by distillation.

The acid, which in this distillation comes over after the first phlegm, is an exceeding strong and concentrated vinegar. It is known by the title of *spirit of verdegris*. Zwelfer, and after him M. Le Fevre in his chymistry, bestows extraordinary praises on this spirit; pretending that it will produce the salt of coral, and others of the same kind, without losing any of its virtue, or ceasing to be acid; so as to remain still capable of performing other operations of the same nature. But Mr. Boerhaave and Mr. Lemerier positively deny the fact; and with good reason, having formed their judgements on their own experiments,

Yet I can hardly think both Zwelfer and le Fevre would have affirmed a thing of this nature, in such a positive and confident manner, if they had been convinced in their minds that it was false. We must suppose that those chymists examined the matter with too little attention, and were misled by some fallacious appearance. Probably they may have compared this concentrated vinegar with common distilled vinegar; they may have put to their coral an equal dose thereof; and, after saturation, they may have distilled off the superfluous liquor, which may have effervesced with fresh coral and dissolved it. Surprised at this effect they may have imagined that their acid had lost none of its strength, and that it had the virtue of converting into salt any quantity of coral, or such other matters, without any prejudice to its acidity. A rash conclusion: which certainly they never could have made, if they had carried the experiment far enough; if they had dissolved a third or fourth quantity of coral in their vinegar: for they would have been thereby convin-

ced that the spirit of verdegris, like all other acid spirits deposits and leaves its acid in absorbent matters; and that if the liquor, which they drew off by distillation from their first salt of coral, was still acid, and capable of dissolving fresh coral, nothing could be inferred from thence but that spirit of verdegris is an exceedingly concentrated vinegar, which, in the same quantity of liquor, contains much more acid than the strongest distilled vinegar prepared in the common way; that therefore a much smaller dose thereof is required to convert a given quantity of coral into salt; and that the liquor, which they distilled from their first salt, still retained some of its virtue, only because it was replete with much more acid than could be neutralized by the coral. But a love of the marvellous so prepossesses the mind of man, that it often hinders him from perceiving the most obvious facts. This is the fault of all the ancient chymists in general; and I believe the only reason why we find their books stuffed with so many unsucceeding experiments was, that their heated imaginations frequently represented things to them otherwise than they really were.

P R O C E S S III.

The Acid of Vinegar combined with Lead. Ceruse. Salt or Sugar of Lead. This combination decomposed.

INTO the glass head of a cucurbit, put thin plates of lead, and secure them so that they may not fall out when the head is put upon the cucurbit. Fit on this head to a wide-mouthed cucurbit containing some vinegar. Set it in a sand bath; lute on a receiver, and distill with a gentle heat for ten or twelve hours. Then take off the head: in it you will find the leaden plates covered, and, in a man-

manner, cruſted over with a white matter. This being brushed off with a hare's foot is what we call *ceruſe*. The leaden plates thus cleaned may be employed again for the ſame purpoſe, till they be wholly converted into *ceruſe* by repeated diſtillations. During the operation there will come over into the receiver a liquor ſomewhat turbid and whitish. This is a diſtilled vinegar in which ſome lead is diſſolved.

Reduce a quantity of *ceruſe* into powder; put it into a matraſs: pour on it twelve or fifteen times as much diſtilled vinegar; ſet the matraſs in a ſand-bath; leave the matter in digeſtion for a day, ſhaking it from time to time: then decant your liquor, and keep it apart. Pour freſh vinegar on what is left in the matraſs, and digeſt as before. Proceed thus till you have diſſolved one half, or two thirds of the *ceruſe*,

Evaporate to a pellicle the liquors you poured off from the *ceruſe*, and ſet them in a cool place. Greyiſh cryſtals will ſhoot therein. Decant the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Proceed thus evaporating and cryſtallizing, as long as any cryſtals will ſhoot. Diſſolve your cryſtals in diſtilled vinegar, and evaporate the ſolution, which will then ſhoot into whiter and purer cryſtals. This is the *ſalt or ſugar of lead*.

OBSERVATIONS.

Lead is eaſily diſſolved by the acid of vinegar. If it be barely expoſed to the vapour of that acid, its ſurface is corroded, and converted into a kind of calx or white ruſt, much uſed in painting, and known by the name of *ceruſe* or *white lead*. But this preparation of lead is not combined with a ſufficient quantity of acid to convert it into a ſalt: it is no more than lead divided and opened by the acid

acid of vinegar; a matter which is to lead what verdegris is to copper. And therefore, if you desire to combine ceruse with the quantity of acid necessary to convert it into a true neutral salt, you must treat it in the same manner as we did verdegris, in order to procure crystals of copper; that is, you must dissolve it in distilled vinegar, as the process directs.

The salt of lead is not very white when it first shoots; and for this reason it is dissolved again in distilled vinegar, and crystallized a second time. If salt of lead be repeatedly dissolved in distilled vinegar, and the liquor evaporated, it will grow thick; but cannot be desiccated without great difficulty. If the same operation be oftener repeated, this quality will be thereby more and more increased; till at last it will remain on the fire like an oil, or melted wax: it coagulates as it cools, and then looks, at first sight, like a metallic mass, somewhat resembling silver. This matter runs with a very gentle heat, almost as easily as wax.

The salt of lead hath a saccharine taste, which hath procured it the name also of sugar of lead. For this reason when wine begins to turn sour, the ready way to cure it of that disagreeable taste is, to substitute a sweet one which is not disagreeable to the taste, by mixing therewith ceruse, litharge, or some such preparation of lead: for the acid of the wine dissolves the lead, and therewith forms a sugar of lead, which remains mixed with the wine, and hath a taste which, joined with that of the wine, is not unpleasant. But, as lead is one of the most dangerous poisons we know, this method ought never to be practised; and whoever employs such pernicious drug deserves to be most severely punished. Yet some thing very like this happens every day, and must needs have very bad consequences; while there is no body to blame,
and

and those to whom the thing may prove fatal can have no mistrust of it.

All the retailers of wine have a custom of filling their bottles on a counter covered with lead, having a hole in the middle, into which a leaden pipe is soldered. The wine which they spill on the counter, in filling the bottles, runs through this pipe into a leaden vessel below. In that it usually stands the whole day, or perhaps several days; after which it is taken out of the leaden vessel, and mixed with other wine, or put into the bottle of some petty customer. But, alas for the man to whose lot such wine falls! He must feel the fatal effects from it; and the danger to which he is exposed is so much the greater, the longer the wine hath stood in the leaden vessel, and thereby acquired more of a noxious quality. We daily see cruel distempers, among the common people, occasioned by such causes, which are not sufficiently attended to.

Wine that is not kept in close vessels is apt to turn sour very soon, especially in the summer; and the retailers of wine have observed that their drippings, thus collected in vessels of lead, are not liable to this inconvenience. This is what hath established among them the practice I am speaking against. As they see only the good effects thereof, and know nothing of its ill consequences, we cannot be angry with them. It is natural to think, that as lead hath the property of keeping wine cool it may by that means prevent its growing sour for some time; and persons who are not versant in chymistry can hardly suspect that wine is preserved from being prick'd only by being converted into a kind of poison. Yet this is the very case: for lead doth not hinder the wine from growing sour; but, uniting with its acid, as soon as it appears, and forming therewith a sugar of lead, changes the taste thereof

thereof as hath been said, and hinders the acid from affecting the palate.

Hence it appears how much it were to be wished that the use of those counters covered with lead were abolished entirely. I am informed, by a chymist zealous for the public good *, that he represented this matter unto the magistrates several years ago. It is not to be doubted, that, when the dealers in wine know the ill consequences attending this practice, they will with pleasure sacrifice the small benefit they receive from it to the public safety.

It is easy to prove whether or no a suspected wine contains lead. You need only pour into it a little oil of tartar *per deliquium*; or, if you have not that at hand, a lye of the ashes of green wood. If there be any lead dissolved in it, the liquor will immediately grow turbid, and the lead will precipitate in the form of a white powder; because the sugar of lead it contains, being a neutral salt whose basis is a metal, is decomposed by the fixed alkali, which separates that metal from the acid. Lead thus separated from the acid of vinegar by an alkali is called *magistery of lead*.

Ceruse, or white lead, is also a very dangerous poison. It is a pigment very much used, being the only white that can be applied with oil. This white is the most common, or perhaps the only cause of those dreadful colicks, with which painters,

* Mr. Rouelle, whom I have had occasion to mention several times in this work with the honour which he deserves, and with whom I went through a course of chymistry when I was a student in medicine. It must be observed, to the praise of this ingenious artist, that he is the first Frenchman that ever gave courses of chymistry. In these he explains the operations according to the true and sound theory of the science drawn from the writings of Beccher, Stahl, Juncker, Boyle, Boerhaave, Hoffman, and many other excellent chymists, whom it would be tedious to mention here, as well as from the memoirs of the most celebrated academies, particularly those of the academy of sciences at Paris.

and all that work in colours, are frequently afflicted. This induced me to examine all the substances capable of affording a white, in order to find one, if possible, which might be substituted for white lead: but, after a vast number of experiments, I had the mortification to be convinced that all whites, even the brightest and most beautiful, which are not metallic, produce nothing, when ground with oil, but greys, or dirty yellows. There is still something to be hoped for in whites obtainable from certain metallic substances: but, as every one of those matters may be suspected of some noxious quality, long experience alone will remove our just apprehensions of danger from every thing afforded by such substances.

To return to the salt of lead: it may be decomposed by distillation without additament. In order to perform this, you must put the salt of lead into a glass or stone retort, leaving a full third thereof empty, and distill in a reverberating furnace with degrees of fire. A spirit rises, which fills the receiver with clouds. When nothing more will come over with a fire that will make the retort red-hot, let the vessels cool, and then unlute them. You will find in the receiver an austere liquor, which is inflammable; or, at least, an inflammable spirit may be obtained from it, if about one half thereof be drawn off by distillation in a glass alembic. The retort in which the salt of lead was decomposed contains, at the end of the operation, a blackish matter: this is lead, which will resume its metallic form on being melted in a crucible; because the acid by which it was dissolved, and from which it hath been separated, being of a very oily nature, hath left in it a sufficient quantity of phlogiston.

What is most remarkable in this decomposition of salt of lead is the inflammable spirit which it yields,

yields, though the vinegar which entered into the composition of the salt seemed to contain none at all.



CH A P. VII.

OF THE PUTRID FERMENTATION OF VEGETABLE SUBSTANCES.

PROCESS I.

The Putrefaction of Vegetables.

FILL a hoghead with green plants, and tread them down a little ; or, if the vegetables be dry and hard substances, divide them into minute parts, and steep them a little in water to moisten them : then leave them, or the green plants, in the vessel, uncovered and exposed to the open air By degrees a heat will arise in the center of the vessel, which will continue increasing daily, at last grow very strong, and be communicated to the whole mass. As long as the heat is moderate, the plants will retain their natural smell and taste. As the heat increases, both these will gradually alter, and at last become very disagreeable, much like those of putrid animal substances, The plants will then be tender as if they had been boiled ; or even be reduced to a kind of pap, more or less liquid according to the quantity of moisture they contained before.

OBSERVATIONS.

Almost all vegetable matters are susceptible of putrefaction ; but some of them rot sooner, and others

others more slowly. As putrefaction is only a species of fermentation, the effect whereof is to change entirely the state of the acid, by combining it with a portion of the earth and oil of the mixt, which are so attenuated that from this union there results a new saline substance in which no acid is discernible; which on the contrary hath the properties of an alkali, but rendered volatile; it is plain, that, the nearer the acid of a plant set to putrefy is to this state, the sooner will the putrefaction of that plant be completed. Accordingly all plants that contain a volatile alkali ready formed, or from which it can be obtained by distillation, are the most disposed to putrefaction.

Those plants, in which the acid is very manifest and sensible, are less apt to putrefy; because all their acid must undergo the change above specified. But vegetable matters, whose acid is entangled and clogged by several of their other principles, must be still longer elaborated, before they can be reduced to the condition into which complete putrefaction brings all vegetables. The earthy and oily parts, in which the acids of these substances are sheathed, must be attenuated and divided by a previous fermentation, which, from those parts subtilized and united with the acid, forms an ardent spirit, wherein the acid is more perceptible than in the almost insipid, or saccharine, juices out of which it is produced. The acid contained in the ardent spirit must be still further disengaged, before it can enter into the combination of a volatile alkali: consequently the ardent spirit must undergo a sort of decomposition; its acid must be rendered more sensible, and be brought to the same condition as the acid of plants in which it manifests all its properties.

Hence it appears that the spirituous and acetous fermentations are only preparatives, which nature makes use of, for bringing certain vegetable mat-

ters to putrefaction. These fermentations therefore must be considered as advances towards that putrefaction, in which they terminate, or rather as the first stages of putrefaction itself. This is the opinion of Mr. Stahl, who hath treated this subject with great sagacity, and thrown much light upon it.

Mr. Boerhaave is not altogether of the same mind. He considers putrefaction as something foreign to fermentation; as an operation independent of it, and very different from it. He gives the title of fermentation to that intestine and spontaneous motion only which produces an ardent spirit, and changes it into an acid. He found his opinion on this, that the circumstances attending putrefaction are different from those which accompany spirituous and acetous fermentation; that the product of putrefaction is very different from the products of these fermentations; and lastly, that all vegetable and animal substances are susceptible of putrefaction, whereas only some kinds of them are capable of fermentation properly so called.

Mr. Boerhaave is so far right, that we ought not to confound together operations which differ in several respects, and result in different productions; but Mr. Stahl's opinion must nevertheless be looked on as highly probable, or rather absolutely true. For it doth not necessarily follow, from the difference between the circumstances and productions of fermentative motions, that the operations have no relation to, or connection with, each other. They may nevertheless be considered as different steps of one and the same operation: and if all vegetable and animal matters are not susceptible of the three degrees of fermentation, we can only infer from thence that there are mixts, in which the whole work of fermentation is yet to do; and that there are others whose principles are so disposed that they are in the same condition as if they had already undergone

dergone the first, or even the second, degree of fermentation; and consequently such mixts are susceptible only of the second, or perhaps the third, degree of fermentation.

Mr. Stahl therefore says very judiciously, that, far from denying putrefaction to be a fermentation, we ought on the contrary to consider all fermentation as no other than putrefaction. Matters susceptible of the spirituous and acetous fermentation do but pass through these previous alterations in their way to complete putrefaction. On this principle wine and vinegar are only liquors that had begun to putrefy, but were stopt at the first or second stage of their putrefaction. This is so true, that, if a fermenting liquor be left to itself in the open air, and in a due degree of heat, it will proceed directly, without any stop, to perfect putrefaction.

The acetous fermentation is attended with more heat than the spirituous, and the putrid with still more than the acetous. The heat of putrefying plants is sometimes so considerable, that, when they are not too moist, and are stacked up in great heaps, they take fire and burn violently. Of this there are frequent instances in hay-ricks.

P R O C E S S II.

Putrefied Vegetable substances analyzed.

PUT the putrefied plants you mean to analyze into a glass cucurbit, and set it in a sand-bath. Fit to it a head; lute on a receiver; distill with a gentle fire, and a limpid fetid liquor will come over. Continue the distillation till the matter contained in the retort be almost dry.

Then unlute your vessels, and keep the liquor you find in the receiver by itself. Put the matter remaining in the cucurbit into a retort, and distill

with a graduated heat. There will rise white vapours; a pretty considerable quantity of liquor nearly like that of the former distillation; a volatile salt in a concrete form; and a black oil, which towards the end will be very thick. In the retort there will remain a black charred matter, which being burnt in the open air will fall into ashes, from which no fixed alkali can be extracted.

By means of a funnel separate your oil from the aqueous liquor. Distill this liquor with a gentle heat. You will by this means obtain a volatile salt like that of animals; of which you may also get some, by the same means, from the liquor which came over in the first distillation.

OBSERVATIONS.

This analysis shews the changes which putrefaction produces in vegetable matters. Scarce any of their principles are now to be discerned. They now yield no aromatic liquor; no essential oil; no acid; and consequently no essential salt, ardent spirit, or fixed alkali: in a word, whatever their natures were before putrefaction, they are all alike when they have once undergone this fermentative motion in its full extent. Nothing can then be obtained from them but phlegm, a volatile alkali, a fetid oil, and an insipid earth.

Almost all these changes are owing to the transmutation of the acid, which is depraved by putrefaction, and combined with a portion of the oil and subtilized earth of the mixt; so that the result of their union is a volatile alkali. Now, as the fixed alkali, found in the ashes of unputrefied plants, is only the most fixed part of their earth and of their acid, closely united together by the igneous motion, it is not surprising that, when all the acid, with a part of the earth is subtilized, and volatilized by putrefaction, no fixed alkali can be

be found in the ashes of putrefied vegetables. The alteration which the acid suffers by the putrefactive motion is, in my opinion, the greatest it can undergo, without being entirely destroyed and decomposed, so as to be no longer a salt.

We have seen it, in the mineral kingdom, in its greatest purity and strength. Its combination with oil, and the other alterations it undergoes, in the vegetable kingdom, have shewn it weakened and disguised. The changes it suffers by the spirituous and acetous fermentation, have exhibited it in other forms. And, lastly, putrefaction disfigures it completely, and, in some sort, changes its very nature, so that it cannot be distinguished. In the animal kingdom we find it nearly in the same condition: for though the vegetable substances, on which animals feed, do not undergo direct putrefaction, in its full extent, before they are converted into animal juices, yet they suffer most of the alterations produced by putrefaction; so that when they have acquired the qualities necessary to their becoming an actual nutritious animal juice, they are within one step of complete putrefaction. For this reason all animal substances are very apt to putrefy, and are unsusceptible of the first degrees of fermentation. But this discussion belongs to the animal kingdom, of which we are now going to treat in the third part of these elements; the theory of putrefaction serving to introduce it, and naturally leading us to it.



P A R T III.

Of Operations on Animal substances,



C H A P I.

OF MILK.

P R O C E S S I.

Milk separated into Butter, Curd, and Whey: instanced in Cow's-Milk.

PUT new cow's-milk into a flat earthen pan, and set it in a temperate heat. In ten or twelve hours time there will gather on its surface a thick matter, of a somewhat yellowish white: this is called *cream*. Gently skim off this cream with a spoon, letting the milk you take up with it run off. Put all this cream into another vessel, and keep it. The milk thus skimmed will not be quite so thick as before: nor will it be of such a dead white, but have a little blueish cast. If all the cream be not separated from it, more will gather on its surface after some time, which must be taken off as the former. In two or three days the skimmed milk will coagulate into a soft mass called *curd*, and then it tastes and smells sour.

Cut this curd across in several places. It will immediately discharge a large quantity of *serum*. Put

Put the whole into a clean linen cloth; hang it up, and underneath it set a vessel to receive the serum as it drops. When the aqueous part hath done dripping, there will remain in the filter a white substance somewhat harder than the curdled milk. This substance is called *cheese*, and the serum separated from it is known by the name of *whey*.

OBSERVATIONS.

The milk of animals, that feed only on vegetables, is of all animal matters the least removed from the vegetable nature. The truth of this will be demonstrated by the experiments we shall produce by and by, for the further analysis of milk. For this reason we judged, with Mr. Boerhaave, that it was proper to begin the analysis of animals by examining this liquor.

Most chymists justly consider milk as of the same nature with chyle. Indeed there is great reason to think, that, except some small differences to be afterwards taken notice of, these two matters are nearly the same. They are both of a dead white colour, like that of an emulsion; which proves that, like emulsions, they consist of an oily matter divided, diffused, and suspended, but not perfectly dissolved, in an aqueous liquor.

It is not surprising that these liquors should resemble emulsions; for they are produced in the same manner, and may very justly be called *animal emulsions*. For how are vegetable substances converted into chyle and milk in an animal body? They are bruised, divided, and triturated by mastication and digestion, as perfectly, at least, as the matters pounded in a mortar to make an emulsion; and must thereby undergo the same changes as those matters; that is, their oily parts, being attenuated by those motions, must be mixed with and lodged between

between the aqueous parts, but not dissolved therein; because they do not, in the bodies of animals, meet with saline matters, sufficiently disentangled and active, to unite intimately with them, and by that means render them soluble in water.

Nevertheless chyle and milk, though produced in the same manner as emulsions, and very much resembling them, differ greatly from them in some respects; owing chiefly to the time they remain in the bodies of animals, their being heated while there, the elaborations they undergo therein, and the animal juices commixed with them.

New milk hath a mild agreeable taste, without any saline pungency; nor hath any chymical trial discovered in it either an acid or an alkali. Yet it is certain that the juices of plants, out of which milk is formed, contain many saline matters and especially acids: accordingly milk also contains the same; but the acids are so sheathed and combined, that they are not perceptible. The case is the same with all the other liquors intended to constitute part of an animal body: there is no perceptible acid in any of them.

Hence it may be inferred that one of the principal changes which vegetables undergo, in order to their being converted into an animal substance, consists in this, that their acids are combined, entangled, and sheathed in such a manner that they become imperceptible, and exert none of their properties.

Milk left to itself, without the help of distillation, or any additament whatever, undergoes a sort of decomposition. It runs into a kind of spontaneous analysis; which doth not indeed reduce it to its first principles, yet separates it into three distinct substances, as the process shews; namely into cream, or the buttery fat part, into curd or cheese, and into serum or whey: which shews that those
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three substances of which milk consists, are only mixed and blended together, but not intimately united.

The first parts, being the lightest, rise gradually to the surface of the liquor as they separate from the rest : and this forms the cream.

Cream as skimmed from the surface of milk, is not however the pure buttery or fat part ; is still mixed with many particles of cheese and whey, which must be separated in order to reduce it into butter. The most simple, and at the same time the best method of effecting this, is daily practised by the country people. It consists in beating or churning the cream, in a vessel contrived for that purpose, with the flat side of a circular piece of wood, in the center of which a staff is fixed. One would think that the motion, impressed on the cream by this instrument, should rather serve to blend more intimately the particles of butter, cheese, and whey, of which it consists, than to separate them from each other ; as this motion seems perfectly adapted to divide and attenuate those particles. But, if we consider what passes on this occasion, we shall soon perceive that the motion by which butter is churned is nothing like triture : for churning is no other, properly speaking, than a continually repeated compression, the effect whereof is to squeeze out from amongst the buttery particles those of cheese and whey mixed therewith ; by which means the particles of butter are brought into contact with each other, unite, and adhere together.

Milk, whether skimmed or no, grows sour of itself, and curdles in a few days. When it is newly curdled, the cheese and whey seem to be united, and to make but one mass : but these two matters separate spontaneously from each other, with the greatest ease, and in a very short time.

The acidity, which milk naturally contracts in the

the space of a few days, must be considered as the effect of a fermenting motion, which discovers in that liquor an acid that was not perceptible before. This, properly speaking, is an acetous fermentation, which milk passes through in its way to putrefaction; and it soon follows, especially if the milk be exposed to a hot air.

If, instead of leaving milk to grow sour and curdle of itself, an acid be mixed therewith, while it is yet sweet and newly milked, it immediately coagulates; which gives reason to think that its curdling naturally is the effect of the acid, which discovers itself therein as it grows stale.

The coagulation of milk may also be considerably accelerated, by setting it in a sand-bath gently heated; or by mixing therewith a little of what, in the language of the dairy, is called *runnet*; which is nothing but some curdled and half-digested milk taken from the stomach of a calf: or both these methods may be employed at once, which will produce the effect still more expeditiously.

It is not difficult to find out the cause of these effects. The runnet, which is milk already curdled and grown sour, is an actual ferment to sweet milk, disposing it to turn sour much more readily: for though milk, when thus hastily curdled by the runnet, hath not a manifestly acid taste, yet it is certain that this acid begins to exert itself. The proof thereof is, that, being exposed to the same degree of heat with milk equally new, that is not mixed with this ferment, it turns sour much sooner. As to the effect of heat in coagulating milk, there is nothing extraordinary in it: we know how much it promotes and accelerates all fermentative motion. The whole of this perfectly agrees with what we said before concerning fermentation.

Fixed alkalis also coagulate milk; but at the same time they separate the whey from the cheese, which floats on the liquor in clots. They give the milk a

ruffet

ruſſet colour inclining to red ; which may ariſe from their attacking the fat part.

The ſeparation of milk into butter, cheeſe, and whey, is a kind of imperfect analyſis thereof, or rather the beginning of one. In order to render it complete, we muſt examine each of theſe ſubſtances ſeparately, and find the principles of which they conſiſt. This we ſhall endeavour to do in the following proceſs.

P R O C E S S II

Butter analysed by diſtillation.

INTO a glaſs retort put the quantity of freſh butter you intend to diſtill. Set the retort in a reverberatory ; apply a receiver ; and let your fire be very gentle at firſt. The butter will melt, and there will come over ſome drops of clear water, which will have the peculiar ſmell of freſh butter, and ſhew ſome tokens of acidity. If the fire be increaſed a little, the butter will ſeem to boil : a froth will gather on its ſurface, and the phlegm, ſtill continuing to run, will gradually come to ſmell juſt like butter clarified in order to be preſerved. Its acidity will be ſtronger and more manifeſt than that of the firſt drops that came over.

Soon after this, by increaſing the fire a little more, there will riſe an oil, having nearly the ſame degree of fluidity as fat oils ; but it will grow thicker as the diſtillation advances, and at laſt will fix in the receiver when it cools. It will be accompanied with ſome drops of liquor, the acidity whereof will always increaſe, while its quantity decreases, as the diſtillation advances.

While this thick oil is diſtilling, the butter contained in the retort, which at firſt ſeemed to boil, will be calm and ſmooth, without the leaſt appearance.

ance of ebullition ; though the heat be then much greater than when it boiled. Continue the distillation, constantly increasing the fire by degrees as you find it necessary for the elevation of the thick oil. This oil, or rather this kind of butter, will be at last of a russet colour. There will arise along with it some white vapours exceeding sharp and pungent.

When you observe that nothing more comes over, though the retort be quite red-hot, let the vessels cool, and unlute them. You will find in the receiver an aqueous acid liquor, a fluid oil, and a kind of fixed brown butter. Break the retort and you will find therein a charred matter ; the surface of which, where it touched the glass, will be of a shining black, and have a fine polish.

OBSERVATIONS.

The analysis of butter proves that this substance, which is an oily matter in a concrete form, owes its consistence to the acid only, with which the oily part is combined : that is, it follows the general rule frequently mentioned above in treating of other oily compounds ; the consistence whereof we shewed to be so much the firmer, the more acid they contain. The first portions of oil that come over in the distillation of butter are fluid, because a pretty considerable quantity of acid rose before them, which being mixed with the phlegm gives it the acidity we took notice of.

This oil, being freed from its acid, and by that means rendered fluid, rises first ; because it is by the same means rendered lighter. The kind of butter that comes over afterwards, though it be fixed, is nevertheless far from having the same consistence as it had before distillation ; because it loses much of its acid in the operation. This acid is what rises in the form of white vapours. These vapours are,

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at least, as pungent and irritating as the sulphureous acid or volatile alkalis : but their smell is different ; it hath a resemblance, or rather is the same, with that which rises from butter, when it is burnt and browned in an open vessel. But, when concentrated and collected in close vessels, as in the distillation of butter, they are vastly stronger : they irritate the throat so as to inflame it ; they are exceeding sharp and pungent to the smell, and are so hurtful to the eyes that they quickly inflame them, as in an ophthalmy and make them shed abundance of tears. The great volatility of this acid is entirely owing to a portion of the phlogiston of the butter with which it is still combined.

It may be asked why butter, or the oily part of milk which hath the consistence of a fixed oil, is more replete with an acid than the oils of the vegetables whereof the milk was formed ; as these oils are almost all fluid, which indicates their containing less acid before than after they were digested in the body of an animal. This must appear the more extraordinary, because the acid contained in the liquors of animals is sheathed and imperceptible, and consequently incapable of combining with the oils of vegetables so as to give them this consistence.

I think it will be easy to give a satisfactory answer to this question, if it be considered that the oils, which exist in the vegetable juices whereof the milk is formed, are far from being combined with the whole acid of those vegetables ; because there is hardly a plant that doth not yield a great deal of acid, even without the help of fire. Now, there is reason to think, that one of the principal effects of digestion is, to combine and unite this acid, with the oily parts of vegetables, more intimately than it was before.

The further we advance in the analysis of animals, the more we shall be convinced, that, in the different

rent elaborations, which vegetable substances undergo in order to their being changed into the nutritious juices of animals, nature employs all her powers to expell, destroy, or at least, weaken and blunt the acids, so as to render them absolutely imperceptible. One of the best means by which she can effect this, is the combining and uniting them intimately with the oily parts: and this operation she probably begins in digestion. She gets rid of most part of the acids contained in the aliments, by thus uniting them with the oils contained in those aliments. Hence arises the consistence of butter, which is the fat part of milk, that is, of a liquor half-changed into an animal juice.

This explication furnishes us also with the reason why acids agree so ill with people of weak and delicate constitutions. The motion and heat in their bodies is not sufficient to effect a due combination of the acids with the oils. Hence it comes to pass, that, during and after digestion, they find in their bowels the bad effects of those acids, in the disorder commonly called the *heart-burn*. Hence also it is that such people receive great benefit from the use of absorbents, which uniting with the acids neutralize them, and relieve nature when she has not strength enough herself to get the better of them.

To return to our analysis of butter: we took notice in the process that butter seems to boil with a very moderate heat at the beginning of the distillation, and that in the course of the operation the ebullition ceases entirely, though the heat be then greatly increased; which is contrary to the general rule. The reason is that butter, though a seemingly homogeneous mass, contains nevertheless some particles of cheese and whey. The particles of whey, being much the lightest, endeavour, on the first application of heat, to extricate themselves from amongst the particles of butter, and to rise in distillation.

distillation. Thus they form the drops of acidulated phlegm which come over at first, and, in struggling to get free, lift up the buttery parts, or actually boil, which occasions the ebullition observable at the beginning of the process. When they are once separated, the melted butter remains calm and smooth, without boiling. If you want to make it boil you must apply a much greater degree of heat; which you cannot do in close vessels, without spoiling the whole operation: because the degree of heat necessary for that purpose would force up the butter in substance, which would rush over into the receiver, without any decomposition. Indeed if the vessels were luted they would be in danger of bursting.

As to the caseous parts, which are mixed with fresh butter, they also separate at the beginning of the distillation, when the butter is melted, and gather on its surface in a scum. These particles of cheese and whey, which are heterogeneous to butter, help to make it spoil the sooner. And for this reason those who want to keep butter a long time, without the use of salt, melt it, and thereby evaporate the aqueous parts. The lightest portion of the particles of cheese rises to the surface, and is skimmed off; the rest remains at the bottom of the vessel, from which the butter is easily separated; by decanting it while it is yet fluid.

Butter may also be distilled, by incorporating it with some additament which will yield no principle itself, nor retain any of those of the butter. I have distilled it in this manner with the additament of fine sand: the operation succeeds very well, is sooner finished, and more easily conducted: but I chose to describe here the manner of doing it without additament; because the several changes, which the butter undergoes in the retort during the operation, may be better observed.

If you desire to convert the butter wholly into
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oil, you must take the fixed matter you find in the receiver, and distill it once more, or oftner, according to the degree of fluidity you want to give it. The case is the same with this matter as with all other thick oils, which, the oftner they are distilled, grow always the more fluid, because in every distillation they are separated from part of the acid, to which alone they owe their consistence.

PROCESS III.

The Curd of Milk analyzed by distillation.

INTO a glass retort put some new curd, having first drained it thoroughly of all its whey, and even squeezed it in a linen cloth to express all its moisture. Distill it as you did butter. There will come over at first an acidulated phlegm, smelling like cheese or whey. As the distillation advances, the acidity of this phlegm will increase.

When it begins to run but very slowly raise your fire. There will come over a yellow oil, somewhat empyreumatic. Continue the distillation, still increasing the fire by degrees as occasion requires. The oil and acid phlegm will continue to rise; the phlegm growing gradually more acid, and the oil deeper coloured, and more empyreumatic. At last, when the retort is almost red-hot, there comes off a second black oil, of the consistence of turpentine, very empyreumatic, and so heavy as to sink in water. In the retort will be left a considerable quantity of charred matter.

OBSERVATIONS.

Cheese-curd barely drained, till no more whey will drip from it, is not entirely freed thereof; and for this reason we directed it to be pressed in a linen cloth,

cloth, before it be put into the retort to be distilled. Without this precaution, the remaining whey would rise in a considerable quantity on the first application of heat; and, instead of analyzing the curd only, we should at the same time analyze the whey also. This is to be understood of green curd and new-made cheese; for, if it be suffered to grow old it will at length dry of itself; but then we should not obtain from it the same principles by distillation; as it corrupts and begins to grow putrid after some time, especially if it be not mixed with some seasoning to preserve it.

The first phlegm that rises in this distillation, as in that of butter, is a portion of the whey that was left in the cheese, notwithstanding its being well pressed. This phlegm grows gradually more acid, being the vehicle of the acids of the cheese, which are forced up along with it by the fire.

The acid obtained from this matter is less in quantity, and weaker, than that of butter: and accordingly the oil distilled from cheese is not fixed like that of butter. Yet it is remarkable that the last empyreumatic oil, which is as thick as turpentine, is heavier than water: a property which it probably derives from the quantity of acid it retains.

The quantity of charred matter, which remains in the retort after the distillation of cheese, is much greater than that left by butter, which proves that the former contains a much greater quantity of earth. These coals are exceeding difficult to burn and reduce to ashes. I have kept them red-hot, in the open air, and in a very strong fire, above six hours, continually stirring them, in order to bring the under parts to the surface, that they might be burnt, yet I could not consume them entirely. They even deflagrated afterwards with nitre, as if they had not been burnt at all; and yet, during the whole time of their calcination, there appeared

constantly a small flame, like that of charcoal, on the surface of the matter.

P R O C E S S IV.

Whey analyzed.

E Vaporate two or three quarts of whey almost to dryness in a *balneum mariae*; and distill the extract, or residuum, in a retort set in a reverberating furnace, with degrees of fire, according to the general rule. At first some phlegm will come over; then a lemon-coloured acid spirit; and afterwards a pretty thick oil. There will remain in the retort a charred matter, which being exposed to the air grows moist. Lixivate it with rain water, and evaporate the lixivium: it will yield you crystals of sea-salt. Dry the charred matter, and burn it in the open air with a strong fire, till it be reduced into ashes. A lixivium of these ashes will shew some tokens of a fixed alkali.

O B S E R V A T I O N S.

Milk, as was said before, separates naturally and spontaneously into three sorts of substances, the analyses whereof being put together make a complete analysis of this animal liquor. I know no author that hath delivered the analysis of butter and cheese; so that the processes here given for analyzing these two substances are taken from the experiments I thought proper to make, in order to obtain the necessary lights in this matter. As for the analysis of whey, it is taken from one of Mr. Geoffroy's memoirs, containing experiments on several animal substances, which was published in 1732. It is there so particularly and so well described, that it was needless for me to attempt it anew.

It will appear, on examining the three analyses of the substances whereof milk consists, that none of them yields a volatile alkali: which I think very worthy of notice; as it is, I believe, the only animal matter from which such a salt cannot be obtained. It is true, the milk of animals that feed on vegetables may be considered as an intermediate liquor between vegetable and animal substances; as an imperfect animal juice, which still retains much of the vegetable nature: and we actually find that milk almost always hath, at least in part, the properties of those plants with which the animals that yield it are fed. Yet, as it cannot be formed in the body of the animal, without mixing with several of its juices that are entirely perfected, and become purely animal, it must appear strange that the analysis thereof should not afford the least vestige of that principle, which all other animal matters yield in the greatest plenty.

I imagine the reason of this may be found in the use to which milk is destined. It is intended for the nourishment of animals of the same species with those in whose bodies it is produced. Consequently it ought as much as possible to resemble the juices of the food which is proper for those animals. Now, as animals that live only on vegetables could not be properly nourished by animal matters, for which nature itself hath even given them an aversion, it is not surprising that the milk of such animals should be free from any mixture of such things as are unsuitable to the young ones whom it is designed to nourish. There is reason therefore to think that nature hath disposed the organs, in which the secretion of milk is performed, so as to separate it entirely from all the animal juices first mixed with it? and this I take to be the principal difference between milk and chyle; the latter being necessarily blended with the saliva, the gastric

gastric and pancreatic juices, the bile and lymph of the animals in which it is formed. Hence it may be concluded, that, if a quantity of chyle could be collected sufficient to enable us to analyze it, the analysis thereof would differ from that of milk, in this chiefly that it would yield a great deal of volatile alkali, of which milk, as hath been said, yields none at all.

The same thing probably takes place in carnivorous animals. It is certain that those animals chuse to eat the flesh of such others only as feed upon vegetables; and that nothing but extreme hunger, and the absolute want of more agreeable food, will force them to eat the flesh of other carnivorous animals. Wolves, which greedily devour sheep, goats, &c, seldom eat foxes, cats, polecats, &c. though these animals are not strong enough to resist them. Foxes, cats, and birds of prey, that make such terrible havock among wild fowl, and other sorts of game, do not devour one another. This being laid down, there is reason to think that the milk of carnivorous animals is something of the nature of the flesh of those animals that feed on vegetables, and which they chuse to eat, and not of the nature of their own flesh; as the milk of animals that feed on vegetables is analogous to the juice of vegetables, and when analyzed yields no volatile alkali, though every other part of their body does.

But whatever be the nature of milk, and of whatever ingredients it be formed, it always contains the three several substances above mentioned; namely, the fat, or buttery part, properly so called, the cheely, and the ferous part, the last of which we are now examining. It is, properly speaking, the phlegm of the milk, and consists almost entirely of water. For this reason it is proper to lessen the quantity thereof considerably by evaporation, so that its other principles, being concentra-
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ted and brought nearer together, may become much more sensible. There is no danger of losing any essential part of the whey in the evaporation, if it be performed in the *balneum maria*, with such a gentle heat as may carry off the aqueous parts only: this greatly shortens the analysis, which will prove exceeding long and tedious, if all the water be distilled off in close vessels.

As whey is chiefly the aqueous part of milk, as said above, it must contain all the principles thereof that are soluble in water; that is, its saline and saponaceous parts. And accordingly the analysis thereof shews that it contains an oil, rendered perfectly saponaceous by an acid; that is, made perfectly miscible with water. This quality of the oil contained in whey appears from the perfect transparency of that liquor, which we know is the mark of a complete dissolution. In the distillation of whey, the saponaceous matter contained therein is decomposed; the saline part rises first, as being the lightest; this is the acid taken notice of in the process; after which the oil, now separated from the principle which rendered it miscible with water, comes over in its natural form, and doth not afterwards mix with the aqueous part.

Besides the saponaceous matter, whey contains also another saline substance; namely, sea salt: this is obtained by lixiviating the *caput mortuum* left in the retort, which, because of its fixedness, cannot rise with the other principles in distillation. To this salt it is owing that what remains in the retort after distillation grows moist in the air; for we know that sea salt thoroughly dried hath this property.

The fixed alkaline salt, obtained from the *caput mortuum* burnt to ashes, proves that milk still retains something of the vegetable nature: for the following analysis will shew us that matters purely animal yield none at all.

C H A P.



C H A P. II.

OF THE SUBSTANCES WHICH COMPOSE AN ANIMAL BODY.

P R O C E S S I.

Blood analyzed. Instanced in Bullock's blood.

IN a *balneum mariæ* evaporate all the moisture of the blood that the heat of boiling water will carry off. There will remain an almost dry matter. Put this dried blood into a glass retort, and distill with degrees of heat, till nothing more will come over, even when the retort is quite red-hot, and ready to melt. A brownish phlegm will rise at first: this will soon be impregnated with a little volatile alkali, and then will come over a yellow oil, a very pungent volatile spirit, a volatile salt in a concrete form, which will adhere to the sides of the receiver; and, at last, a black oil, as thick as pitch. There will be left in the retort a charred matter, which being burnt yields no fixed alkali.

O B S E R V A T I O N S.

Blood, which is carried by the circulation into all the parts of the animal body, and furnishes the matter of all the secretions, must be considered as a liquor consisting of almost all the fluids necessary to the animal machine: so that the analysis thereof is a sort of general, though imperfect, analysis of an animal.

Blood drawn from the body of an animal, and

set by in a vessel, coagulates as it grows cold; and some time afterwards the *coagulum* discharges a yellowish *serum* or lymph; and in the midst thereof swims the red part, which continues curdled. These two substances, when analyzed, yield nearly the same principles; and in that respect seem to differ but little from each other. Though the serum of blood be naturally in a fluid form, yet it hath also a great tendency to coagulate, and a certain degree of heat applied to it, either by water, or by a naked fire, will curdle it. Spirit of wine mixed with this liquor produces on it the same effect as heat.

Blood, while circulating in the body of a healthy animal, and when newly taken from it, hath a mild taste, which discovers nothing like either an acid or an alkali; nor doth it shew any sign of either the one or the other in chymical trials. When tasted with attention it betrays something like a savour of sea-salt; because it actually contains a little thereof, which is found in the charred matter left in the retort after distillation, when carefully examined.

We shewed that milk also contains a little of this salt. It enters the bodies of animals with the food they eat, which contains more or less thereof according to its nature. It plainly suffers no alteration by undergoing the digestions, and passing through the strainers, of the animal body. The case is the same with the other neutral salts which have a fixed alkali for their basis: we find them unchanged in the juices of animals into whose bodies they have been introduced. They are incapable of combining, as acids do, with the oily parts; and so are dissolved by the aqueous fluids, of which nature makes use to free herself from those salts, and discharge them out of the body; as shall be shewn when we come to speak of urine and sweat.

Blood, like all other animal-matters, is, properly speaking,

speaking, susceptible of no fermentation but that of putrefaction. Yet it turns somewhat sour before it putrefies. This small degree of acetous fermentation is most sensible in flesh; and especially in the flesh of young animals, such as calves, lambs, chickens, &c.

The quantity of pure water, which blood, in its natural state, contains, is very considerable and makes almost seven eighths thereof. If it be distilled, without being first dried, the operation will be much longer, because it will be necessary to draw off all this insipid phlegm with a gentle fire. There is no reason to apprehend that, by drying blood in open vessels as directed, any of its other principles will be carried off with its phlegm: for it contains no other substance that is volatile enough to rise with the warmth of a *balneum mariæ*. This may be proved by putting some undried blood into a glass cucurbit, fitting thereto a head and receiver, and distilling, in a *balneum mariæ*, all that the heat of the bath, not exceeding the heat of boiling water, will raise: for, when nothing more will come over, you will find in the receiver an insipid phlegm only, scarce differing from pure water, except in having a faint smell like that of blood; wherein it resembles all the phlegms that rise first in distillation, which always retain something of the smell of the matters from which they were drawn. That part of the blood, which remains in the cucurbit after this first distillation, being put into a retort, and distilled with a stronger fire, yields exactly the same principles, and in the same proportion, as blood dried in open vessels in the *balneum mariæ*: so that, if this phlegm of blood contains any principles, the quantity thereof is so small as to be scarce perceptible.

The volatile alkali that rises with the oil, when blood is distilled in a retort with a degree of heat greater than that of boiling water, is either the production

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production of the fire, or arises from the decomposition of an ammoniacal salt, of which it made a part. For we shall see, when we come to treat of this saline substance, that it is so extremely volatile as to exceed, in that respect, almost all other bodies that we know: and therefore if this volatile alkali pre-existed formally in the blood, uncombined with any other matter capable, in some measure, of fixing it, it would rise at first almost spontaneously, or at least on the first application of the gentlest heat. We have an instance of this in blood, or any other animal matter, that is perfectly putrefied; which containing a volatile alkali, either formed or extricated by putrefaction, lets go this principle when distilled, even before the first phlegm: and, for this reason, when putrefied blood is to be analyzed, it must by no means be dried, like fresh blood, before distillation; for all the volatile alkali would by that means be dissipated and lost at once.

The volatile alkali obtained from blood that hath not undergone putrefaction affords matter of some speculation. Indeed the separation of this salt from blood requires a degree of heat, vastly greater than that which is necessary to make it rise, when it is perfectly formed and disentangled: and this gives room to think that it is the result of a combination formed by the fire, during the distillation. But then this same degree of heat neither separates or forms any volatile alkali in a great number of plants, or in milk, as hath been shewn. Yet it cannot be supposed that the blood of animals, which feed only on those plants or on milk, is any other than these very matters digested and rendered perfectly animal substances: whence it must be concluded, that, when vegetable substances are converted into animal substances, they undergo such alterations as render them capable of yielding, when analyzed, a principle that was not discoverable in them before. Now we know that this same

principle, that is, the volatile alkali, is the product of putrefaction, or, which is the same thing, of the last degree of fermentation; and this, I think, makes the opinion of those more than probable, who believe that trituration and mechanical motion are not the only causes, that effect the conversion of food into an animal juice, but that fermentation hath a great share in this change. It is true, we do not find, in animal matters, any manifest token of an ardent spirit, an acid, or a volatile alkali; nor, consequently, any substance that is an evident production of any of the three different degrees of fermentation: and yet, as substances perfectly animalized are exactly in the same state with vegetables that have undergone the first, and even the second, degree of fermentation, so that they are susceptible of putrefaction only; (or, at least, if they shew at first some faint tokens of acidity, they run immediately and rapidly into complete putrefaction;) it is nevertheless probable that vegetable matters, in order to their becoming animal substances, undergo certain changes and alterations, which have some resemblance with those produced by fermentation.

This opinion is further confirmed by two other analogies, between animal matters, and vegetables advanced to the last stage of fermentation; which is, that they yield neither an essential oil nor a fixed alkali: for the coal, that remains in the retort after the distillation of blood, being burnt in an open fire, discovers no fixed alkali in its ashes.

The want of a fixed alkali in animal matters arises from hence, that their acid is nearly in the same state with the acid of vegetable matters which have undergone putrefaction; that is, it is so subtilized and attenuated, as to be fit to enter into the combination of a volatile alkali, and is no longer so intimately united with the fixed earth as to produce therewith a fixed alkali in the fire.

Though

Though blood and other animal matters afford no fixed alkali, but, on the contrary, yield much volatile alkali, it doth not therefore follow that all the acid, which those substances contained before they were analyzed, is employed in the production of a volatile alkali. We shall hereafter take notice of an animal matter which contains a great deal of acid: and, not to depart from our present subject, it doth not appear to me to be a settled point among chymists, whether or no blood, when analyzed, yields a portion manifestly acid, and possessing all the properties of an acid.

Mr. Boerhaave, with some other chymists, makes no mention of any acid in his analysis of blood. Mr. Homberg, on the contrary, says * expressly, that he constantly obtained an acid from the blood and flesh of different sorts of animals, of which he analyzed a great number. Mr. Boerhaave's authority is very respectable, and of great weight: On the other hand, Mr. Homberg's experiments are very conclusive, seem to be made with great care, and are all affirmative. This apparent diversity in the same analysis, delivered by these two great men, determined me to analyze blood myself, and to examine scrupulously all the principles I could obtain from it.

I therefore distilled some bullock's blood in a retort with degrees of fire. Some phlegm came over first; and then a volatile spirit. I changed my receiver; and on increasing the fire there rose, with the volatile spirit, a yellow oil, a volatile salt in a concrete form, a russet liquor which smelled strong of volatile alkali, and seemed at first to be only a spirit impregnated with much of that salt: at last came a very thick fetid oil.

In this brown liquor, which comes off towards the end of the distillation. Mr. Homberg affirms the acid to be contained; but, as it certainly is re-

* Memoirs of the Academy of Sciences for 1712.

plete with a volatile alkali also, he alledges that it contains, at the same time, both a volatile alkali and the animal acid; that these two salts are distinct from each other, and not combined together in the form of an ammoniacal salt; that each of consequence possesses its peculiar properties; and that this liquor is at the same time both acid and alkaline; that it effervesces with acids, and also changes the blue colours of plants to red.

The alkaline quality of this liquor is very evident, and discovers itself in every chymical trial; but the same cannot be said of its acid property. I dropped some of it on blue paper, the colour of which did not at first change in the least, nor acquire the faintest shade of redness. This experiment almost determined me to conclude that Mr. Homberg was mistaken: but some time afterwards I perceived that the blue paper began to turn red where it had been wetted, and that the red colour grew deeper and deeper as the paper dried: and this convinced me that this liquor actually contains an acid, as Mr. Homberg asserted; but, that the volatile alkali in this liquor, being much more copious than the acid, had first entered the paper, and hindered the acid from turning it red as usual; and that, as the alkali evaporated, the acid began to act, and produce the customary effect. Hence we see that the acid of blood, though extricated by distillation, is not easily perceived at first, because of the great proportion of volatile alkali, with which the liquor containing it is impregnated. This is probably what prevented its being discovered by several chymists, who, it seems, did not suspect its existence, and therefore did not look for it.

Mr. Homberg takes no notice of this little difficulty in his memoir: but he relates an experiment which might have given occasion to suspect it. It is in his analysis of human blood. As the acid in
human

human blood is in less quantity, and less perceptible, than in the blood of animals that live wholly on vegetables, he directs a second distillation of the brown liquor, which contains at once both the volatile alkali and the acid, till very little thereof be left in the retort. *This residuum*, says he, *contains a very perceptible and distinct acid*. There is reason to believe, from Mr. Homberg's directing the saline liquor to be distilled again, that he did not find the acid sufficiently perceptible in it at first. Now a second distillation is a very good way to render it much more sensible. For though this animal acid be volatile, the volatile alkali is still vastly more so; and therefore if the liquor containing both these saline substances be distilled, the volatile alkali must needs rise first, and leave the acid alone, or almost alone, at the bottom of the retort. This is exactly the case in our experiment on blue paper; the operation being here performed with a small quantity, and much more expeditiously, as appears from our account of it.

It is not at all surprising that the volatile alkali and animal acid, though confounded in the same liquor should not be united together and converted into a neutral ammoniacal salt. Mr. Homberg pretends that these two saline matters do not act upon each other, because they are too much dephlegmated. The oily parts, with which they are both loaded, may also contribute thereto: nor is this unprecedented; the same thing being observed of the acid and the volatile alkali of several vegetable substances.

Mr. Homberg, justly suspecting that there might be some difference between the condition of the acid in the blood of animals that feed altogether on vegetables, and that in the blood of those that feed only on flesh, examined likewise, by decomposition, the blood and the flesh of some carnivorous animals. In these also he found an acid; and it doth

not appear that he observed any great difference, in this respect, between their blood and that of other animals. The difference he found between the blood of young, and that of grown, or old, animals, with respect to the acid, seems, by his account, to be more considerable; the blood of the former containing much more of it than that of the latter: and this is so much the more probable, as we know that the flesh of young animals grows sour, before it putrefies, more sensibly than that of old ones.

We shall conclude this head with a remark concerning the management required in distilling blood. When the operation is advanced to a certain point, the matter contained in the retort often swells so as to stop the neck of that vessel entirely, and by that means makes it burst with an explosion. To avoid this inconvenience, a very small quantity of blood must be put into the retort, and the fire must be governed very warily. I have also found that this accident may generally be prevented by mixing the blood with some matter that can afford no principle by distillation; such as pounded glass or fine sand.

PROCESS II.

Flesh analyzed. Instanced in Beef.

INTO an alembic or retort, placed in a sand-bath, put some lean beef, from which you have carefully separated all the fat. Distill till nothing more will rise. In this first distillation a phlegm will come over, weighing at least half the mass of the distilled flesh. In the retort you will find a matter almost dry, which you must afterwards distill, with a naked fire, in a reverberating furnace, taking the usual

usual precautions. There will come over at first, a little phlegm replete with volatile alkali; then a volatile alkali in a dry form, which will stick to the sides of the vessel; and also a thick oil. After the distillation there will be left in the retort a black, shining, light coal. Burn it to ashes in the open air, and lixivate those ashes: the water of the lixivium will have no alkaline property, but will shew some tokens of its containing a little sea-salt.

OBSERVATIONS.

This analysis of beef is taken from a memoir given in by Mr. Geoffroy in 1730, the purpose of which was a chymical examination of the meat commonly used to make broth. The flesh of an animal, as appears from the process, yields much the same principles with its blood: and it cannot be otherwise; because it is formed all together of materials furnished by the blood.

Mr. Geoffroy observes that the first phlegm, drawn off from it in the *balneum mariæ*, produces a white precipitate in a solution of corrosive sublimate; which shews it to contain a little volatile alkali: but the quantity thereof must be very small; seeing the phlegm that contains it smells only like broth, and not like a volatile alkali; one particle of which, we know, is capable of affecting the organ of smelling very sensibly. As to the acid of flesh, there is great reason to believe that it is conditioned exactly like that of blood.

The ashes of the *caput mortuum* of flesh, burnt in an open fire, attract the moisture of the air, as Mr. Geoffroy remarks, and increase in weight, though they contain no fixed alkali. However, this is not at all surprising; since they contain some sea-salt, the known property whereof is to grow moist in the air.

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The flesh of animals contains much matter that is soluble in water. Mr. Geoffroy examined separately that part of flesh which water is capable of dissolving. With this view he boiled four ounces of beef with three pints of water, in a very close vessel, and repeated the operation six times with equal quantities of fresh water; in order to extract, as far as possible, all the juices of the meat. These broths he put all altogether, the last of them having but a faint smell of very weak veal broth: he evaporated them over a slow fire, filtering them towards the end of the evaporation, to separate an earthy part; and there remained in the vessel a moderately solid extract, which soon grew moist in the air. This extract, being analyzed, yielded a dram and two grains of volatile salt, which adhered to the sides of the receiver; not in ramifications, as volatile salts usually do, but in flat crystals, mostly in the form of parallelopipeds. The spirit and the oil, which came over together after the volatile salt, weighed thirty eight grains. Salt of tartar being mixed with this volatile salt seemed to increase its strength; which gives room to suspect that the latter contains an ammoniacal salt.

The charred matter left in the retort weighed but six grains. Its lixivium gave some tokens of sea-salt, by making a white precipitate in a solution of quick-silver. The mass of fleshy fibres, that was exhausted by boiling, being dried and analyzed in the same manner, yielded a volatile spirit, a volatile salt in a concrete form, which stuck to the sides of the receiver in ramifications as usual; and a thick fetid oil. There now remained in the retort a charred matter, which being burnt in the open air, or not burnt, shewed not the least sign of its containing any saline matter.

This method of analyzing flesh, by boiling it at first in water, in order to extract all that can be dissolved by this menstruum, shews us that animal
flesh

flesh contains an oil, which is in a saponaceous state; for the extract made therefrom, by water, yields in distillation a considerable quantity of oil, which was perfectly dissolved in the water, while that extract was in the diluted state of broth, and before it was analyzed.

It is remarkable that the volatile salt, yielded by the extract of flesh, is different from that which is obtained out of the flesh, itself when nothing hath been extracted from it. This salt, as Mr. Geoffroy observed, differs from the common volatile alkalis in the form of its crystals; which made that chymist justly consider it as a salt of a somewhat ammoniacal nature; a kind of essential salt of flesh.

There is reason to think that this salt, when dissolved in the water in which we boil flesh, is separated therefrom, by the action of fire, with more ease than while it remains combined with the other principles, in the substance of the flesh; that its separation, in the latter case, requiring a greater degree of heat, it is thereby decomposed; and that the volatile alkali, which is obtained from flesh distilled in the usual manner, is only one of the parts that constituted the ammoniacal salt thereby decomposed.

The charred matter remaining, after the distillation of flesh first exhausted by boiling, yields nothing saline; because the sea-salt, which is the only fixed salt it could contain, was dissolved by the water together with the matter of the extract.

Mr. Geoffroy likewise examined what parts of flesh spirit of wine is capable of dissolving. For this purpose he took four ounces of beef, dried in the *balneum mariae*, poured on it an equal weight of well rectified spirit of wine, and left the whole in digestion for a considerable time. The spirit extracted from the beef a weak tincture, and separated from it some drops of oil: it acquired a brown colour, and a faint smell. Mr. Geoffroy found,

found, by several experiments, that the spirit of wine had taken up a portion of the ammoniacal, or essential, salt of the flesh. With respect to the oil, if any at all were dissolved, it could be but very little; for that which the spirit separated, and which retained its natural form, was certainly not dissolved: seeing in that case it would not have been perceived, but would have made a homogeneous liquor, to appearance, with the spirit of wine.

P R O C E S S III.

Bones analyzed. Instanced in Ox-bones.

CUT into pieces the bones of a leg of beef, carefully separating all the marrow. Put them in to a retort, and distill them in a reverberating furnace, as usual. A phlegm will come over first; then a volatile spirit, which will become stronger and stronger; afterwards a volatile salt in a dry form, with some oil; and, lastly, a black oil, with a little more volatile salt. There will be left in the retort a charred matter, from which a little sea-salt may be extracted. Reduce this charred matter to ashes, by burning it in the open air. These ashes will give some slight tokens of a fixed alkali.

O B S E R V A T I O N S.

The analysis of bones proves that they consist of the same principles with flesh and blood; and the same may be said, in general, of all matters that are truly animal, or that actually constitute any part of an animal.

Nevertheless we find in the ashes of bones somewhat of an alkaline quality; seeing they make a red precipitate in a solution of corrosive sublimate

and yet a true fixed alkali cannot be obtained from them. These ashes are probably in the same case with quick lime, which hath certain properties of alkaline salts, though no salt of that kind can be extracted from it.

Mr. Geoffroy analyzed bones in the same manner as he did flesh; that is, he at first made a strong decoction of them with water, and then examined and distilled apart the extract afforded him by that decoction, and the bones deprived of that extract. On this analysis he made two remarkable observations.

The first is, that bones yielded to boiling water their principles and their volatile salts, both sooner and more copiously than flesh did: for in the analysis which Mr. Geoffroy made of several sorts of flesh, though he robbed them in a manner of all their principles by boiling, yet their dried fibres afterwards yielded a considerable quantity of volatile salt; whereas the bones, of which he had made an extract by boiling, afforded him but a very small quantity thereof when analyzed.

The second observation worthy of notice which Mr. Geoffroy made on his analysis of bones is this; the salt, which, as was shewn in the analysis of flesh, was resolved by the water wherein he boiled the flesh, and consequently rose when he distilled the extract obtained from that decoction, and crystallized in the form of parallelopipeds, took a quite different turn in the analysis of bones. None of it appeared in distilling the extract made by decoction, but rose in distilling the boiled bones, that were exhausted of almost all their other principles by the decoction with water. These differences probably arise from the different contexture of the animal matters in which they are observed.

This analysis of bones may serve as a pattern for analysing all the solid parts of animals, such as horns, hoofs, ivory, &c.

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PROCESS IV.

Animal Fat analyzed. Instanced in Mutton-Suet.

PUT as much mutton-suet as you please into a glass retort, only taking care that the vessel be but half full; and distill with degrees of fire as usual. A phlegm smelling of the suet will rise first, and soon grow very acid. After this some drops of oil will come over, and be followed by a matter like oil, in appearance, when it comes over; but it will fix in the receiver, and acquire a consistence somewhat softer than suet. This kind of butter of suet will continue to rise to the end of the distillation; and there will be left in the retort a small quantity of charred matter.

OBSERVATIONS.

Though animal fat be a substance that hath passed through all the strainers of the body; though it hath undergone all the elaborations necessary to form an animal matter, and become itself part of the animal, it contains nevertheless, as its analysis shews, principles differing greatly from those of all other animal matters: so that it must be classed, in some sort, by itself.

It consists almost entirely of oil: but this oil is in a concrete form, and observes the general rule of all concreted oily matters, which owe their consistence wholly to the acid that is combined with them. The rule is evidently so general that it extends even to the animal kingdom, where, in all other instances, acids seem to be almost annihilated.

All we said above on the subject of butter must be applied here: for animal fat, properly so called and butter, do not, in my opinion, differ sensibly from

from each other, with respect to their analysis. And therefore there is great reason to believe that what is butter in chyle, or milk, becomes fat when fixed in the animal body. It is a kind of repository in which nature lays up and confines the acid that is unnecessary to the animal composition, and which she could not any other way eliminate.

I made choice of mutton-suet for an instance of the analysis of fat; because this fat, being the firmest of any, must contain a stronger and more perceptible acid.

When it is thus distilled, the part which remains fixed hath much less consistence than the suet had before; which arises from its having lost part of its acid. Repeated distillations will deprive it of a much greater quantity thereof, and so reduce it into an oil that will always remain clear and fluid.

Not one particle of volatile alkali is obtained by distilling suet; but then the experiment will not succeed as it ought, unless care be taken to free the suet perfectly from all the membranes, and all the particles of flesh and blood that may be mixed with it; for, if it should be distilled without this precaution, those heterogeneous matters mingled with it would yield a great deal of volatile alkali in distillation; which might impose on the artist, and make him think the salt came actually from the suet. Suet that hath been often melted, as the tallow, for instance, of which candles are made, is sufficiently purified: of this I made use in my analysis, and it yielded me no volatile alkali; at least I could perceive none.

In conclusion, all that hath been said, on several occasions, touching the properties of concreted oily matters, may be applied to suet. I shall only observe here that it is one of those that manifest no acidity, and consequently that in its natural state it is not soluble in spirit of wine, and only becomes soluble in that menstruum by degrees, as its

acid is extricated by repeated distillations: and on this account it ought to be classed with bee's wax, and other oily compounds of that kind.

PROCESS V.

Eggs analyzed. Instanced in Pullet's Eggs

PUT some hen's eggs in water, and boil them till they be hard. Then separate the yolks from the whites. Cut the whites into little bits; put them into a glass cucurbit; fit on a head and receiver; distill in a *balneum mariae* with degrees of fire, raising it towards the end to the strongest heat which that bath can give; that is, to the heat of boiling water. There will come over an aqueous liquor, or insipid phlegm; the quantity whereof will be very considerable, seeing it will make about nine tenths of the whole mass of the whites of the eggs. Continue your distillation, and keep the water in the bath constantly boiling, till not a drop more of liquor will ascend from the alembic. Then unlute your vessels. In the cucurbit you will find your whites of eggs considerably shrunk in their bulk. They will look like little bits of brown glass and be hard and brittle.

Put this residuum into a glass retort, and distill, as usual, in a reverberating furnace with degrees of heat. There will come over a volatile oily spirit, a yellow oil, a volatile salt in a dry form, and, at last, a black thick oil. There will be left in the retort a charred matter.

Reduce also into the smallest pieces you can the hard yolks of the eggs which you separated from the whites. Set them in a pan over a gentle fire: stir them with a stick till they turn a little brown, and discharge a substance like melted marrow. Then put them into a new strong canvas bag, and

press

press them between two iron plates well heated; whereby you will obtain a considerable quantity of a yellow oil.

Let what remains in the bag be distilled in a retort set in a reverberating furnace: it will give you the same principles as you got from the whites.

OBSERVATIONS.

Of the two perfectly distinct substances that constitute the egg, the yolk contains the embryo of the chick, and is destined to hatch it: the white is to serve for the nourishment of the chick when it is formed.

These two matters, though they contain the very same principles, yet differ considerably from each other; and chiefly in this, that their principles are not in the same proportions.

The white of an egg contains so much phlegm, that it seems to consist almost totally thereof. All the aqueous liquor, obtained by distilling it in the *balneum marie*, is, properly speaking, nothing but pure water; for no chymical trial can discover in it either an acid or a volatile alkali; or any very perceptible oily part. And yet it must contain some oil, because the liquor that rises last is a little bitterish to the taste, and smells somewhat of empyreuma. But the principles from which it derives these properties are in too small quantities to be distinctly perceived.

If, instead of distilling the hard white of an egg, with a view to draw off the great quantity of water it contains, you leave it some time in an air that is not too dry, the greatest part of its moisture separates spontaneously, and becomes very sensible. In all probability this is the effect of a beginning putrefaction, which attenuates this substance, and breaks its texture. The liquor thus discharged by the white of an egg thoroughly dissolves gum-resins,

resins, and particularly myrrh. If you desire to dissolve myrrh in this manner, cut a hard boiled egg in halves; take out the yelk; put the powdered gum-resin into the cavity left by the yelk; join the two halves of the white; fasten them together with a thread, and hang them up in a cellar. In a few days time the myrrh will be dissolved by the moisture that issues from the white of the egg, and will drop into the vessel placed underneath to receive it. This liquor is improperly called *oil of myrrh per deliquium*.

All the properties of the whites of eggs, as well as the principles obtained by analyzing them, are the same with those of the lymphatic part of the blood; so that there is a great resemblance between these two substances.

As to the yelk, it is plain from its analysis that oil is the predominant principle thereof. If the yelk of an egg be mixed with water, the oil with which it is replete, and which is by nature very minutely divided, diffuses itself through the whole liquor, and remains suspended therein by means of its viscosity. The liquor at the same time becomes milk-white like an emulsion, and is in fact a true animal emulsion.

In order to obtain the oil of eggs by expression with the more ease, care must be taken to chuse eggs that are seven or eight days old; because they are then a little less viscous. Nevertheless their viscosity is still so great that they will not easily yield their oil by expression: and therefore, in order to attenuate and destroy entirely this viscosity, they must be torrefied before they are put to be pressed.

The oil of eggs, like all other oily animal matters, seems analogous to the fat oils of vegetables. It hath all the properties that characterise those oils. Its colour is yellow, and it smells and tastes a little of the empyreuma, occasioned by torrefying the yelks. It is rendered somewhat less disagreeable by being

being exposed to the dew for thirty or forty nights, if care be taken to stir it often in the mean time.

To conclude : all the principles, both in the yelk and the white of an egg, are the same as those found in blood, flesh, and all other matters that are perfectly animal.



CH A P. III.

OF THE EXCREMENTS OF ANIMALS.

P R O C E S S I.

*Dung analyzed. Instanced in Human Excrement.
Mr. Homberg's Phosphorus.*

TAKE any quantity you please of human excrement, and distill it in a glass alembic set in the *balneum mariæ*. You will obtain an aqueous, clear, insipid liquor; which will nevertheless have a disagreeable odour. Having urged the distillation as far as is possible, with the heat of this bath, unlute your vessels, and you will find at the bottom of the cucurbite a dry matter, making about an eighth part only of what you put into it. Put this residuum into a glass retort, and distill in a reverberating furnace, with degrees of heat. You will obtain a volatile spirit, and a volatile salt, with a fetid oil; and a charred matter will be left in the retort.

O B S E R V A T I O N S.

Mr. Homberg made a great many experiments on the dung of animals; concerning which he composed two memoirs published in the academy's collection for 1711. That Chymists tells us, that,

in distilling excrement, he aimed not so much at discovering the principles of which it consists, as he was desirous to satisfy a friend of his, who had earnestly entreated him to try whether he could not extract therefrom a clear oil, having no bad smell; because he had seen, as he said, mercury fixed into pure silver by such an oil.

Mr. Homberg's labour had the usual fate of all enterprises of this nature. He actually found the art of drawing from excrement a clear scentless oil; but, in whatever way he applied it to mercury, it produced no change in that metallic substance. However, as Mr. Homberg was a man of sagacity, and knew how to improve every hint offered by his experiments, he made several curious discoveries on this occasion; of which we shall give a concise account, after we have made some remarks on the principles obtained from excrement by the method described in the process.

This substance, consisting of matters subject to putrefaction, hath constantly a fetid smell, like that of all putrid matters; having been for some time confined in a warm, moist place, which we know promotes putrefaction, and even quickly produces it. Yet the analysis thereof proves that it is not putrefied, or at least not entirely so; for all putrefied matters contain a volatile alkali perfectly formed and extricated; and, as this principle rises with less heat than that of boiling water, it always comes over first in distillation. Now we have seen that, with the heat of boiling water, it parts with nothing but an insipid phlegm, containing no volatile alkali: a sure proof that the fecal matter is not completely putrefied,

There is nothing remarkable in the volatile salt and fetid oil, which rise with a degree of heat greater than that of boiling water. They are common productions, of which we have made frequent mention in several of the preceding analyses; and therefore

therefore they need not now detain us from proceeding to give a summary account of Mr. Homberg's chief discoveries.

One of the methods by which Mr. Homberg endeavoured to obtain from excrement a clear oil, without any bad smell, was to separate its earthy and gross parts, by filtering it before he distilled it. "For this purpose he diluted excrement newly discharged with hot water, using a quart of water to an ounce of feces. Then he let the mixture stand to cool, and, the gross parts falling to the bottom, he poured off the water by inclination. This liquor he filtered through brown paper, and evaporated to a pellicle over a gentle fire. There shot in it long crystals of four, five, and six sides, which Mr. Homberg thinks may be called the essential salt of excrement. They resemble salt petre, in some measure, and deflagrate in the fire much like it; with this difference that their flame is red, and they burn slowly; whereas the flame of salt-petre is white and very vivid: probably, says Mr. Homberg, because there is too much of an oily matter in the one, and less in the other.

"Mr. Homberg distilled this salt in a glass retort with degrees of fire, and at last with a very violent one. At first there came over an aqueous liquor, sharp and acid, which was followed by a brown fetid oil, smelling very strong of empyreuma. This distillation he attempted four several times: and each time the matter in the retort took fire, just when the oil began to come off."

The salt which Mr. Homberg obtained from excrement is very remarkable. We shall have occasion to speak of it in another place, and shall only observe here that its nitrous character is by no means ambiguous: its deflagrating on live coals convinced Mr. Homberg of its being a true nitre.

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But its constantly taking fire in the retort, as oft as distilled, is a sure proof that it is a nitrous salt: for nitre only hath the property of thus taking fire in close vessels, and making other combustible matters burn along with it.

The process by which Mr. Homberg at last obtained from excrement a clear oil without any bad smell is curious, and worthy of a place here; on account of the views and occasions of reflection which it may open.

“ Mr. Homberg having tried in vain, by distilling excrement a great many different ways, to obtain from it such an oil as he wanted, resolved to employ fermentation, the effect whereof is to change the disposition of the principles of mixts. With this view he dried some excrement in the water bath; and, having pulverized it, poured thereon six times its weight of phlegm that had been separated from it by distillation, and put the whole into a large glass cucurbite, covered with an inverted vessel that fitted exactly into it, and was close luted. This vessel he set in a *balneum mariæ* for six weeks, keeping up such a gentle heat as would not burn one’s hand; after which he uncovered the cucurbite, and having fitted thereto a head and a receiver, distilled off all the aqueous moisture in the *balneum mariæ* with a very gentle heat. It had now lost almost all its bad smell, which was changed into a faint one. It came over somewhat turbid, whereas it was very clear when put into the cucurbite. Mr. Homberg found this water to have a cosmetic virtue: He gave some of it to persons whose complexion, neck, and arms, were quite spoiled, being turned brown, dry, rough, and like a goose skin: they washed with it once a day, and, by continuing the use of this water, their skin became very soft and white.”

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The dry matter, that remained in the bottom of the cucurbite after distillation, had lost about a twentieth part of its weight; that is, of twenty ounces, put at one time into the cucurbite, somewhat less than nineteen ounces remained. Mr. Homberg suspects that it was not so dry when put into the cucurbite as when it was taken out. Perhaps also the species of fermentation which the matter underwent had attenuated and volatilized some part of it; so that it came over with the phlegm in distillation. The turbidness of that phlegm, which was clear and limpid before, seems to countenance this conjecture.

"The dry matter left in the cucurbite after the first distillation, had not the least smell of feces: on the contrary, it had an agreeable aromatic odour; and the vessel in which Mr. Homberg had digested it, being left open in a corner of his laboratory, acquired in time a strong smell of ambergris. It is surprising, as Mr. Homberg justly observes, that distillation alone should change the abominable smell of excrement into an odour as agreeable as that of ambergris."

"This dry matter he powdered coarsely, and put two ounces thereof at once into a glass retort, that would hold about a pound or a pound and half of water. This he distilled in a sand-bath with a very gentle heat. A small quantity of an aqueous liquor came over first, and then an oil as colourless as spring-water. Mr. Homberg continued the same gentle degree of heat; till the drops began to come off a little redish; and then he changed the receiver, stopping that which contained the clear oil very close with a cork. Having carried on the distillation with a fire gradually augmented, there came over a considerable quantity of red oil; and there remained in the retort a charred matter which burnt very readily."

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The clear oil, without any ill smell, which Mr. Homberg obtained from the fecal matter by this process, was the very thing he was in search of, and which he had been assured would convert mercury into fine fixed silver: yet he ingeniously owns, that, whatever way he applied it, he could never produce any change in that metallic substance. We shall now proceed to the other discoveries made by Mr. Homberg on this occasion.

In his attempt to obtain a clear oil from excrements, he distilled it with different additaments, and amongst the rest with vitriol and alum. He found that the matters left in the retort, when he made use of these salts, being exposed to the open air, took fire of themselves; that they kindled combustible matters; in a word, that they were a true phosphorus, of a species different from all then known. Pursuing these first hints, he sought and found the means of preparing this phosphorus by a way much more expeditious, certain, and easy. His process is this.

“ Take four ounces of feces newly excreted:
“ mix therewith an equal weight of roch-alum
“ coarsely powdered: put the whole into a little
“ iron pan that will hold about a quart of water,
“ and set it over a gentle fire under a chimney.
“ The mixture will melt, and become as liquid as
“ water. Let it boil with a gentle fire, constantly
“ stirring it, breaking it into little crumbs, and
“ scraping off with a spatula whatever sticks to the
“ bottom or sides of the pan; till it be perfectly
“ dry. The pan must from time to time be re-
“ moved from the fire, that it may not grow red-
“ hot, and the matter must be stirred, even while
“ it is off the fire, to prevent too much of it from
“ sticking to the pan. When the matter is per-
“ fectly dried, and in little clots, let it cool, and
“ powder it in a metal mortar. Then put it again
“ into the pan, set it over the fire, and stir it con-
tinually.

“tinually. It will again grow a little moist, and
“adhere together in clots, which must be con-
“tinually bruised and roasted till they be perfectly
“dry; after which they must be suffered to cool,
“and then be pulverized. This powder must be
“returned a third time to the pan, set on the fire,
“roasted and perfectly dried: after which it must
“be reduced to a fine powder, and kept in a paper
“in a dry place. This is the first or preparatory
“operation.

“Take two or three drams of this powder;
“put it into a little matrafs, the belly of which
“will hold an ounce, or an ounce and a half of
“water, and having a neck about six or seven
“inches long. Order it so that your powder shall
“take up no more than about a third part of the
“matrafs. Stop the neck of the matrafs slightly
“with paper: then take a crucible four or five
“inches deep: in the bottom of the crucible put
“three or four spoonfuls of sand: set the matrafs
“on this sand, and in the middle of the crucible,
“so as not to touch its sides. Then fill up the
“crucible with sand, so that the belly of the ma-
“trafs may be quite buried therein. This done,
“place your crucible, with the matrafs, in the
“midst of a little earthen furnace, commonly cal-
“led a *stove*, about eight or ten inches wide a-
“bove, and six inches deep from the mouth to
“the grate. Round the crucible put lighted coals
“about half way up, and when it hath stood thus
“half an hour, fill up with coals to the very top
“of the crucible. Keep up this fire a full half-
“hour longer, or till you see the inside of the ma-
“trafs begin to be red. Then increase your fire,
“by raising your coals above the crucible. Con-
“tinue this strong heat for a full hour, and then
“let the fire go out.

“At the beginning of this operation dense fumes
“will rise out of the matrafs, through the stopple
of

“ of paper. These fumes issue sometimes in such
 “ abundance as to push out the stopple ; which you
 “ must then replace, and slacken the fire. The
 “ fumes cease when the inside of the matrafs be-
 “ gins to grow red ; and then you may increase
 “ the fire without any fear of spoiling your opera-
 “ tion.

“ When the crucible is so cold that it may be
 “ safely taken out of the furnace with one's hand,
 “ you must gradually draw the matrafs out of the
 “ sand, that it may cool slowly, and then stop it
 “ close with a cork.

“ If the matter at the bottom of the matrafs ap-
 “ pear to be in powder when shaken, it is a sign
 “ the operation hath succeeded : but if it be in a
 “ cake, and doth not fall into powder on shaking
 “ the matrafs, it shews that your matter was not
 “ sufficiently roasted and drid in the iron pan, du-
 “ ring the preparatory operation.”

Since Mr. Homberg, Mr. Lemerî the younger hath made a great many experiments on this phosphorus, which may be seen in the memoirs of the Academy for 1714 and 1715. In those memoirs Mr. Lemerî hath shewn that excrement is not the only matter capable of producing this phosphorus with alum ; but that, on the contrary, almost all animal and even vegetable matters are fit for this combination ; that though Mr. Homberg mixed alum in equal quantities only with the fecal matter, it may be used in a much greater proportion, and, in certain cases, will succeed the better ; that, according to the nature of the substances to be worked on, the quantity of that salt may be more or less increased ; and that whatever is added, more than the dose requisite for each matter, serves only to lessen the virtue of the phosphorus, or even destroys it entirely : that the degree of fire applied must be different according to the nature of those matters ; and, lastly, that salts containing exactly the

the same acid with that of alum, or the acid of those salts separated from its basis and reduced into spirit, do not answer in the present operation; which shews, says Mr. Lemerî, that many sulphureous matters may be substituted for excrement in this operation; but that there are no salts, or very few if any, that will succeed in the place of alum. Nevertheless a chymist, who lately communicated to the academy a great number of experiments on this phosphorus, found that any salt containing the vitriolic acid may be substituted for alum.

This phosphorus, made either by Mr. Homberg's or by Mr. Lemerî's method, shines both by day and by night. Besides emitting light, it takes fire soon after it is exposed to the air, and kindles all combustible matters with which it comes in contact; and this without being rubbed or heated.

Mess. Homberg and Lemerî have given the most probable and the most natural explanation of the cause of the accension and other phenomena of this phosphorus. What they say amounts in short to what follows.

Alum is known to be a neutral salt, consisting of the vitriolic acid and a calcareous earth. When this salt is calcined with the fecal matter, or other substances abounding in oil, the volatile principles of these substances such as their phlegm, their salts, and their oils, exhale in the same manner as if they were distilled; and there is nothing left in the matrass, when those principles are dissipated, but a charred matter, like that which is found in retorts wherein such mixts have been decomposed by distillation.

This remainder therefore is nothing but a mixture of alum and charcoal. Now as the acid of this salt, which is the vitriolic, hath a greater affinity with the phlogiston than with any other substance, it will quit its basis to unite with the phlogiston of the coal, and be converted by that union

into a sulphur. And this is the very case; of which we have certain proofs in the operation for preparing this phosphorus: for when, after the volatile principles of the oily matter are drawn off, the fire is encreased, in order to combine closely together the fixed parts that remain in the matras, that is, the alum and the charred matter, we perceive at the mouth of the matras a small blue sulphureous flame, and a pungent smell of burning sulphur. Nay, when the operation is finished, we find a real sulphur sticking in the neck of the matras; and, while the phosphorus is burning, it hath plainly a strong sulphureous smell. It is therefore certain that this phosphorus contains an actual sulphur; that is, a matter disposed to take fire with the greatest ease. But though sulphur be very inflammable, it never takes fire of itself, without being either in contact with some matter that is actually ignited, or else being exposed to a considerable degree of heat. Let us see then what may be the cause of its accension, when it is a constituent part of this phosphorus.

We mentioned just now that the acid of the alum quits its basis, in order to form a sulphur by combining with the phlogiston of the coal. This basis we know to be an earth capable of being converted into lime; and that it is actually converted into quicklime by the calcination necessary to produce the phosphorus. We know that new-made lime hath the property of uniting with water so readily, that it thereby contracts a very great degree of heat. Now when this phosphorus, which is partly constituted of the basis of the alum converted into quicklime, is exposed to the air, the lime instantly attracts the moisture of which the air is always full, and by this means, probably, grows so hot as to fire the sulphur with which it is mixed. Perhaps also the acid of the alum is not totally changed into sulphur: some part thereof may be only half dis-

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gaged from its basis, and in that condition be capable of attracting strongly the humidity of the air, of growing very hot likewise by imbibing the moisture, and so of contributing to the accension of the phosphorus.

There is also room to think that all the phlogiston of the charred matter is not employed in the production of sulphur in this phosphorus, but that some part of it remains in the state of a true coal. The black colour of the unkindled phosphorus, and the red sparkles it emits while burning, sufficiently prove this. The explanation of the accension of this phosphorus, as here given by Mess. Homberg and Lemeris, is very ingenuous, and in the main just; but yet, in my opinion, the subject deserves a more thorough examination.

PROCESS II.

Human Urine analyzed.

PUT some human urine into a glass alembic; set it in a water bath, and distill till there remain only about a fortieth part of what you put in; or else evaporate the urine, in a pan set in the *balneum marie*, till it be reduced to the same quantity. With this heat nothing will exhale but an insipid phlegm, smelling however like urine. The residuum will, as the evaporation advances, become of a darker and darker ruffet, and at last acquire an almost black colour. Mingle this residuum with thrice its weight of sand, and distill it in a retort set in a reverberating furnace, with the usual precautions. At first there will come over a little more insipid phlegm like the former. When the matter is almost dry, a volatile spirit will rise. After this spirit, white vapours will appear on encreasing the fire; a yellow oily liquor will come off, trick-

ling down in veins; and together with this liquor a concrete volatile salt, which will stick to the sides of the receiver. At last there will come over a deep coloured fetid oil. In the retort there will remain a saline earthy residuum, which being lixiviated will yield some sea-salt.

OBSERVATIONS.

Urine must be considered as an aqueous liquor replete with all the saline matters which are of no use to the body, either for nourishment or health: it is a lixivium of animal matters, prepared by nature for dissolving and separating from them all the unnecessary salts. It contains a very large quantity of almost pure phlegm, which evaporates with the heat of a water bath.

The residue of the urine, from which this phlegm is separated by the first distillation, though thereby rendered considerably thicker, doth not coagulate, or curdle in the least, like milk or blood; which shews that it contains no parts analogous to those of these two nutritious liquors. Yet it contains oily and saline parts, disposed like those of truly animal matters; as appears from the spirit, the volatile salt, and the oil, obtained from it by distillation; which are, in every respect, perfectly like the same principles yielded by other animal substances. But, if the animal that made the urine took in with its food any of the neutral salts, which cannot be decomposed by digestion; that is, of those chiefly which consist of acids and alkalis, the urine will contain, over and above the other parts of that animal, almost all the neutral salt that entered into its body. Accordingly human urine is replete with a considerable quantity of sea-salt, because men eat a great deal of it. It is found, after the distillation of the urine, united with the *caput mortuum* left in the retort; because, being

of

of a fixed nature, it doth not rise with the volatile principles in distillation.

Besides this sea-salt, urine contains another salt of a singular nature, which crystallizes differently from sea-salt. In this salt, according to Mr. Marggraff's experiments mentioned on the subject of phosphorus, is contained the acid necessary to produce the phosphorus of urine. There is reason to think that this salt is a sea salt disguised by the fat matters with which it combines during its stay in the animal body.

Mr. Boerhaave calls it the essential salt of urine. If you desire to have it by itself, you must evaporate the urine, with a gentle heat, to the consistence of fresh cream, filter it, and let it stand quiet in a cool place. Crystals will at length shoot therein, and adhere to the sides of the vessel. These crystals are the salt you want: they are brown and oily. If you desire to have them purer, you must dissolve them in warm water, filter the solution, and set it by to shoot. This operation repeated several times will render them clear and transparent. Mr. Schlosser, a young and very promising chymist, is the last who hath made any experiments on this curious salt of urine. Those who are desirous of a particular account of its properties may consult his dissertation printed at Lyden in 1753, as well as Mr. Marggraff's excellent memoirs printed among those of the academy of Berlin.

The chief result of Mr. Schlosser's experiments is, first, that this salt may be obtained from recent urine, and even in greater quantities than from putrid urine, and that too in very little time; seeing it crystallizes in twenty four hours, after due evaporation.

Secondly, that this salt is a neutral ammoniacal salt, consisting of a volatile alkali, (which can never be extracted from it but in a liquid form, like that which is separated from urine by the addition

of lime;) and of an acid of a very singular nature, the most remarkable property of which is, it, being so fixed as to resist the violence of fire, and turn into a sort of glass rather than exhale in vapours. This is that acid which according to Mr. Marggraff's experiments, forms the combination of phosphorus when united with the phlogiston. The other properties of this singular acid are the principal objects of Mr. Marggraff's enquiries.

It follows, in the third place, from Mr. Schloffer's experiments that this acid, being combined to the point of saturation with a common volatile alkali, forms a true, regenerated salt of urine; and that, by this union, the nature of the volatile alkali is so changed, that it cannot afterwards appear by itself in a concrete form, but is always fluid, like that which is extricated by the addition of lime.

If fixed alkalis be mixed with fresh urine, they immediately separate from it a volatile alkali; and if the mixture be quickly put into an alembic, and distilled, the first liquor that rises is a volatile spirit: or else a volatile alkali in a concrete form will rise first, provided the fixed alkali made use of be not liquid, and the urine be dephlegmated.

Herein urine resembles other animal matters: for fixed alkalis produce the same effect on them. This affords us good grounds for believing that all animal matters contain a neutral salt of an ammoniacal nature, which the fixed alkali decomposes, as it doth all other ammoniacal salts. Quick-lime also extricates from urine a volatile alkali, still more quick and pungent than that which is separated by a fixed alkali, and which constantly remains liquid without ever putting on a concrete form: and this is another proof of the existence of the ammoniacal salt above-mentioned; for quick-lime hath just the same effect on sal-ammoniac, as we shall see in its place. Mr. Schloffer's experiments

riments, compared with those now mentioned, seem to shew that the urine contains several distinct sorts of ammoniacal salts.

Of all the liquors which animals afford, urine putrefies the most easily, and by putrefaction parts with, or forms, the greatest quantity of volatile alkali. If it be distilled when putrefied, there comes over first a spirit impregnated with much volatile alkali; then an aqueous liquor, which Van Helmont assures us is a medicine of wonderful efficacy in dissolving the stone in the bladder. When all this water is come over, and the remaining matter is almost dry, there ascends, on increasing the fire, a yellow oil, together with a volatile salt.

After this there remains in the retort a black charred earthy matter, containing a great deal of sea-salt. If this matter be calcined in the open air, in order to consume its phlogiston, and be afterwards lixiviated, all the sea-salt it contains may by this means be easily separated; nothing but its earth being left behind. This *caput mortuum* contains also the materials proper for forming kunkel's phosphorus; and if, instead of calcining it in the open air, it be urged with a violent fire, in close vessels, it will yield a phosphorus: but then all the precautions recommended on the subject of phosphorus must be used; and, in particular, the *caput mortuum* must be lixiviated before it be distilled, in order to free it from part of the sea salt contained therein; because too much of that salt might defeat the operator, by not only melting itself, but melting also the containing vessel during the operation.



C H A P. IV.

OF THE VOLATILE ALKALI.

P R O C E S S I.

Volatile Alkalis rectified and depurated.

MIX together the spirit, the volatile salt, the phlegm, and the oil obtained from any substance whatever. Put the whole into a large wide-mouthed glass body, and thereto fit a head with a large beak. Set this alembic in a water bath, lute on a receiver, and distill with a very gentle heat. There will ascend a spirit strongly impregnated with volatile alkali, and a volatile salt in a concrete form, which must be kept by itself. Then increase your heat to the degree of boiling water; whereupon there will rise a second volatile spirit, somewhat more ponderous than the former, with a light oil that will swim on its surface, and a little concrete volatile salt. Proceed till nothing more will rise with this degree of heat. Keep by itself what came over into the receiver. At the bottom of the cucurbite you will find a thick fetid oil.

Into such another distilling vessel put the spirit and salt that rose first in this distillation, and distill them in the *balneum mariæ* with a heat still gentler than before. A whiter, purer, volatile salt will sublime. Continue the distillation till an aqueous moisture rise, which will begin to dissolve the salt. At the bottom of the vessel will be left a phlegm,

with

with a little oil floating on it. Keep your salt in a bottle well stopped.

OBSERVATIONS.

In the analysis of any substance that yields a volatile alkali, this salt is generally found in the receiver, blended with the other principles of the mixt; which, ascending from the retort in the form of liquors and vapours, dissolve the salt, or at least moisten it, and render it very impure. So that, if you desire to have it without any mixture, recourse must be had to a second distillation, in order to separate it from the heterogeneous matters with which it is confounded.

It is of consequence in this distillation to apply but a very weak degree of heat: because on that depends the success of the operation, inasmuch that, the less heat you employ to sublime the salt, the purer it will be. For, being far more volatile than any of the other principles with which it is mixed, it must evidently rise by itself, if no more heat be applied than is just necessary to elevate it; such a heat being much too weak to raise the oil and phlegm with which it is blended.

Nevertheless, whatever care be taken to govern the heat, it is not possible to hinder this volatile salt from carrying up some portions of the principles mixed with it; those, to wit, with which it is most closely united, and to which it hath by that means communicated a share of its volatility. For this reason it requires a second rectification, which is performed in the same manner as the former. But, seeing it is more volatile and lighter after the first rectification than before, being thereby freed from part of the heterogeneous matters with which it was loaded, a still less degree of heat must be applied in this second rectification.

The oil with which the volatile salt is loaded, when

when but once distilled, is perceivable only by the yellow colour and weight it communicates thereto; because it is closely united therewith, and in a perfectly saponaceous state. This appears from the facility with which volatile salts, even the most oily, dissolve in water, without discovering in the solution any separation of the oily parts, and even without giving it a milky colour. But, in the second rectification, this oil becomes very perceptible; for it then separates, in a great measure, from the salt, and remains at the bottom of the cucurbite, floating on the phlegm, which is also separated from the salt.

The salt is then whiter, more volatile, and purer; yet it is still far from being brought to the utmost degree of purity, even by this second rectification.

It requires a third, a fourth, and even many more rectifications, to purify it perfectly: every rectification separates from it some oily particles: and if you should resolve to go on rectifying till you can separate no more oil, there is reason to think this salt would be entirely decomposed; because there is necessarily a certain quantity of oil in its composition, without which it would not be a volatile alkali. You must therefore desist from rectifying it any further, when you find it very white, and very light; and shut it up in bottles hermetically sealed.

It often happens that volatile salts, though of a beautiful white after rectification, grow yellow after being kept some time in close bottles. This is occasioned by the oil they contain disengaging and discovering itself by degrees. To remedy this inconvenience, Mr. Boerhaave proposes to mingle the volatile salt, which you intend to purify, with four times its weight of pulverized chalk thoroughly dried, and even heated; to put the mixture into a glass alembic, and distill it with a gentle heat. By this means the salt rises exceeding pure and ve-

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ry white; because the chalk absorbs most of its oil, and frees it therefrom. He adds, that volatile salt thus purified may be kept a long time, and will retain all its whiteness.

If a volatile alkali thus purified be combined, to the point of saturation, with an acid, such as the marine acid for instance; the result of this union, as we shall afterwards see, will be a sal ammoniac, from which the volatile alkali may be separated by the intervention of a fixed alkali. A volatile alkali that hath passed through all these trials will then be in the highest degree of purity that chymistry can bring it to, and appears constantly the same, from whatever substance it was originally obtained: which proves that if volatile alkalis, extracted from different vegetable and animal substances, seem to differ from each other in some respects, this can arise only from the heterogeneous matters with which they are mixed; but that, at bottom, they are all constituted of one single principle, which is constantly the same, and exactly alike in them all.

It is of the last consequence, on all occasions, where a volatile alkali is to be distilled in a concrete form, to make use of subliming vessels with very large necks, that it may have room enough to make its way to the receiver with ease; for otherwise it may choak up the passage, and burst the vessels.

PROCESS II.

Volatile Alkalis combined with Acids Sundry Ammoniacal Salts. Sal Ammoniac.

ON a volatile spirit or salt pour gradually any acid whatever. An effervescence will arise, and be more or less violent according to the nature of

of the acid. Go on adding more acid in the same manner, till no effervescence be thereby excited, or at least till it be very small. The liquor will now contain a semi-volatile neutral salt, called an *ammoniacal salt*; which may be obtained in a dry form by crystallizing as usual, or by subliming it in close vessels, after the superfluous moisture hath been drawn off.

OBSERVATIONS.

Volatile alkalis have the same properties with fixed alkalis, fixity only excepted: so that a volatile alkali must produce an effervescence when mixed with acids, and form therewith neutral salts, differing from each other in nothing but the nature of the acid in their composition.

It must be observed that, on this occasion, the point of saturation is very difficult to hit; owing probably to the volatility of the alkali, which, being much lighter than the acid, tends always to possess the uppermost part of the mixture, while the acid sinks to the bottom: whence it comes to pass that the lower part of the liquor is sometimes overcharged with acid, while the upper part is still very alkaline. But it is most eligible that the alkali should predominate in the mixture; because the excess of this principle easily flies off, while the moisture is evaporating, in order to the crystallization or sublimation of the ammoniacal salt; which being only semi-volatile resists the heat longer, and remains perfectly neutral.

If the vitriolic acid be combined with a volatile alkali, and the mixture distilled in a retort to draw off the superfluous moisture, a liquor comes over into the receiver which smells strong of a sulphureous acid. Now, as the acid of vitriol never becomes sulphureous, but when it is combined with an inflammable matter, this experiment is one of those

those

those which demonstrate that volatile alkalis contain a very sensible quantity of inflammable matter. This same liquor tastes of an ammoniacal salt; which proves that it carries up with it some of the neutral salt contained in the mixture. The rest of this salt, which is called *Glauber's secret sal ammoniac*, or *vitriolic sal ammoniac*, sublimes into the neck of the retort. It is very pungent on the tongue, it crackles a little when thrown on a red-hot shovel, and then flies off in vapours.

The ammoniacal salt formed by the acid of nitre exhibits much the same phenomena; but it requires greater care in drying and subliming it, because it hath the property of detonating it all alone, without the addition of any other inflammable matter: and it will infallibly do so, if too strong a fire be applied towards the end of the operation, when it begins to be very dry. This property of detonating by itself it derives from the inflammable matter contained in the volatile alkali which serves for its basis: and this is another demonstrative proof of the existence of such an inflammable matter in the volatile alkali. This salt is called *nitrous sal ammoniac*.

With the vegetable acids, that of vinegar for instance, is formed an ammoniacal salt of a singular nature, and which can scarce be brought to a dry form.

A volatile alkali, combined to the point of saturation with the acid of sea-salt, forms another neutral salt, which takes a concrete form either by sublimation or crystallization. The crystals of this salt are so very soft and fine, that a parcel of it looks like cotton or wool. This is the salt properly called *sal ammoniac*. It is of great use in chymistry and in manufactures: but that which is daily consumed in great quantities is not made in the manner above mentioned. It would come extremely dear, if we had no other way of procuring it, but

but by forming it thus with the acid of sea-salt and a volatile alkali. This salt, or at least the materials of which it is formed, may be found in the fuliginosities and soots of most animal, and of some vegetable substances. The greatest part of what we use comes from Egypt, where vast quantities thereof are made.

The method of preparing sal ammoniac in Egypt was not known among us, till Mess. Lemaire and Granger, two of the academy's correspondents, gave in several memoirs in which that business is described with great accuracy, from their own view on the spot. Their memoirs inform us that chimney-soot alone, without any additament, is the matter from which they obtain their sal ammoniac; that those chimneys under which nothing is burnt but cow's dung furnish the best soot. Six and twenty pounds of that soot yield usually six pounds of sal ammoniac.

" The operation takes up about fifty, or two and
 " fifty hours. The vessels in which they put the
 " soot are ballons of very thin glass, terminating in
 " a neck of fifteen or sixteen lines long and an inch
 " in diameter: but they are not all of the same
 " size. The least contain twelve pounds of soot
 " and the greatest fifty: but they fill them only
 " three quarters full, in order to leave room for
 the sublimation of the salt.

" The furnace, in which they place these ballons
 " consists of four walls built in a quadrangular
 " form. The two front walls are ten, and the
 " sides nine foot long: but they are all five foot
 " high, and ten inches thick. Within the quadrangle
 " formed by these walls three arches run
 " lengthwise from end to end thereof, at the distance
 " of ten inches asunder. The mouth of the
 " furnace is in the middle of one of its front
 " and of an oval form; two foot four inches high
 " and sixteen inches wide.

" T

" The ballons lie in the spaces between the arches
 " of the furnace, which serve instead of a grate to
 " support them. Four of them are usually placed
 " in each interval; which makes sixteen for one
 " furnace. They are set at the distance of about
 " half a foot from each other, and secured in their
 " places with brick and earth. But they leave a-
 " bout four inches on the upper part of the ballon
 " uncovered, with a view to promote the sublima-
 " tion, as they also do six inches of the inferior
 " part, that the heat may the better act on the
 " matters to be sublimed. Things being thus pre-
 " pared they first make a fire with straw, which
 " they continue for an hour. Afterwards they
 " throw in cow's-dung made up in square cakes
 " like bricks. (The want of wood in this country
 " is the reason that they generally make use of this
 " fuel.) These cakes of dung add to the violence
 " of the fire, which they continue in this manner
 " for nineteen hours; after which they increase it
 " considerably for fifteen hours more; and then
 " they slacken it by little and little.

" When the matter contained in the vessels be-
 " gins to grow hot, that is, after six or seven hours
 " baking, it emits a very thick and ill-scented
 " smoke, which continues for fifteen hours. Four
 " hours after that, the sal ammoniac is observed
 " to rise in white flowers, which adhere to the in-
 " side of the neck of the vessel; and those who
 " have the direction of the operation take care,
 " from time to time, to pass an iron rod into the
 " neck of the ballon, in order to preserve a pas-
 " sage through the saline vault, for giving vent to
 " some blueish vapours, which constantly issue out
 " of the vessel during the whole operation."

From this history of the preparation of sal am-
 moniac it appears that soot, and particularly the
 soot of animal matters, either contains abundance
 of this salt perfectly formed, and waiting only for
 sublimation.

sublimation to separate it therefrom, or, at least, that it contains the proper materials for forming it; and that during the operation, which is a kind of distillation of foot, these materials combine together and sublime.

We shewed, in our analysis of foot, that this substance yields by distillation a great deal of volatile alkali; and this is an ingredient which makes at least one half of sal ammoniac. As to the other principle of this salt, I mean the marine acid, this also must needs exist in foot: but it is not so easy to conceive how it should come there.

It is very true that vegetable and animal substances, the only ones that produce foot in burning, contain some portion of sea salt: but then this salt is very fixed, and seems unfit to rise with the acid, the oil, and the subtile earth, of which the volatile alkali is formed. Therefore we must suppose either that its elevation is procured by the force of the fire, aided by the volatility of the matters that exhale in burning; or that, being decomposed by the violence of the combustion, its acid alone rises with the other principles above-mentioned. The latter seems probable enough: for though in the common operations of chymistry the bare force of fire doth not seem sufficient to decompose sea-salt; yet the example of sea-plants, which, before burning, contain this salt in abundance, and whose ashes contain scarce any at all, but are replete with its fixed part, that is, with its alkaline basis, seems to prove that, when this salt is intimately mixed with inflammable matters, it may be destroyed by burning; so that its acid shall desert its basis, and fly off with the foot.

Before the exact method of procuring sal ammoniac was known, it was generally imagined that the manufacturers mixed sea-salt, and even urine, with the foot; because these two substances contain the principles of which this salt consists. But, be-

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shews that the contrary now certainly appears from the above mentioned memoirs, it hath been shewn by Mr. Duhamel, who hath published several memoirs and experiments concerning the composition and decomposition of sal ammoniac, from which we have partly taken what we have already said on this subject, and which will furnish us with some more curious observations; it hath been shewn, I say, in the first of Mr. Duhamel's memoirs printed with those of the academy for 1735, that the addition of sea salt to the foot, from which sal ammoniac is to be extracted, contributes nothing to its production, and cannot increase its quantity. That alone, therefore, which was originally contained in the matters that produced the foot, enters as a principle into the composition of sal ammoniac. We observed also, in treating of the analysis of foot, that Mr. Boerhaave obtained from it a considerable quantity of an ammoniacal salt without any additament.

Sal ammoniac is sometimes found perfectly formed in the neighbourhood of vulcanos. This salt is probably produced from the fuliginosities of vegetable or animal matters consumed by the fire of the vulcano.

Sal ammoniac is often impure, because it carries up with it, in sublimation, some of the black charred matter which ought to be left at the bottom of the vessel: but it is easily purified. For this purpose you need only dissolve it in water, filter the solution, then evaporate and crystallize; by which means you will have a very white and very pure sal ammoniac. You may, if you please, sublime it again in a cucurbite and blind head, with a fire not too brisk. Some of it will rise in the form of a light white powder, called *flowers of sal ammoniac*. These flowers are no other than true sal ammoniac, which hath suffered no decomposition; because the bare action of fire is not capable of separating

the acid and the volatile alkali, of which this neutral salt consists. When you intend to decompose it, you must use the means to be mentioned hereafter.

Though sal ammoniac be only semi-volatile, and requires a considerable heat to sublime it, yet it hath the property of carrying up with it matters that are very fixed and ponderous; such as metallic substances, and some kinds of earths. For medicinal uses we sublime therewith iron, lapis hæmatites, the copper in blue vitriol, &c. and then it takes different names, as *martial flowers of sal ammoniac*, *ens veneris*, and other such denominations, which it borrows from the matters sublimed with it.

PROCESS III.

Sal Ammoniac decomposed by Acids.

INTO a large tubulated glass retort put a small quantity of sal ammoniac in powder; set your retort in a furnace, and lute on a large ballon, as in the distillation of the smoking acids of nitre and sea-salt. Through the hole in your retort pour a quantity of oil of vitriol, or spirit of nitre, equal in weight to your sal ammoniac. An effervescence will instantly follow. The mixture will swell, and discharge white vapours, which will come over into the receiver. Stop the whole in the retort immediately, and let the first vapours pass over, together with some few drops of liquor, which will distill without fire. Then put a few coals into the furnace, and continue the distillation with a very gentle heat; which however must be increased little by little, till nothing more will come off. When the operation is finished, you will find in the receiver a spirit of salt, if you made use of oil of vitriol.

vitriol; or an *aqua regis*, if spirit of nitre was employed: and in the retort will be left a saline mass, which will be either a Glauber's secret sal ammoniac, or a nitrous sal ammoniac, according to the nature of the acid used to decompose the sal ammoniac.

OBSERVATIONS.

Sal ammoniac, which consists of the marine acid united to a volatile alkali, is, with respect to the vitriolic and nitrous acids, just the same as sea-salt is with respect to those acids; that is, the vitriolic and nitrous acids, having a greater affinity, than the marine acid, with volatile as well as fixed alkalis, will decompose the sal ammoniac, by expelling the acid from its basis, and assuming its place, just as they do with regard to sea salt. Most therefore of what was said concerning the decompositions of sea salt, and the distillation of its acid, by the two other acids, must be applied here.

We shall only observe, that, when the acid of sal ammoniac is to be distilled from it by the interposition of the vitriolic or nitrous acid, great care must be taken to put but a very small quantity of this salt into the retort; especially if the acids to be added are concentrated: for, as soon as they mix with the sal ammoniac, a great effervescence arises, and the mixture swells to such a degree, that, unless the quantity in the retort be very small, it may run over altogether into the receiver. It is also proper to take notice that this operation admits of but a small degree of heat, for two reasons; first, because the acid of the sal ammoniac, being very easily dislodged by an acid stronger than it self, rises also very easily; secondly, because the sal ammoniac which is to be decomposed, as well as the ammoniacal salts which result from its decomposition, are semi-volatile, and will sublime in substance if they be exposed to the smallest excess

cess of heat. Moreover, the nitrous sal ammoniac would be in danger of taking fire, and exploding, for a reason frequently mentioned above.

The nitrous sal ammoniac may be decomposed, as well as sal ammoniac, by the vitaiolic acid. But, as the nitrous acid contained in the salt is the strongest of all acids next to the vitriolic, no other acid but this is able to expell it from its basis; in which respect this salt resembles nitre.

Instead of employing the acids of vitriol and nitre to decompose sal ammoniac, we might make use of neutral salts consisting of these acids combined with metallic or earthy bases: but then, as this decomposition can not be effected without a greater degree of heat, there is reason to apprehend that some of the sal ammoniac would be thereby sublimed, before it could be decomposed.

P R O C E S S IV.

Sal Ammoniac decomposed by Fixed Alkalis. Volatile Salt. The Febrifuge of Sylvius.

INTO a glass alembic or retort put sal ammoniac and salt of tartar, pulverized and mixed together in equal quantities. Set your vessel in a proper furnace, and immediately lute on a large receiver. A little volatile spirit will ascend; and a volatile alkali, in a concrete form, very white and beautiful, will sublime into the head, and come over into the receiver, in quantity near two thirds or three fourths of the sal ammoniac used. Continue the distillation, increasing the fire by degrees, till nothing more will sublime. Then unlute the vessels. Put up your volatile salt immediately into a wide-mouthed bottle, and stop it close with a crystal stopple. At the bottom of the retort, or cucurbite,

cucurbite, you will find a saline mass, which, being dissolved and crystallized, will form a salt nearly cubical, having the taste and other properties of sea-salt. This is the *sal febrifugum sylvii*.

OBSERVATIONS.

This decomposition of sal ammoniac is the reverse of that in the preceding process. In the former operation it was shewn that the acid of sal ammoniac may be separated from its bases, by applying to that basis a stronger acid: in the present operation, on the contrary, the basis of this salt is separated from its acid, by presenting to that acid a fixed alkali, wherewith it hath a greater affinity than with the volatile alkali which serves it for a basis.

The action of fixed alkalis upon sal ammoniac is so vigorous and sudden, that, as soon as these two matters are mixed together, the volatile urinous salt rushes out with great activity, even without the help of heat; so that much of it will be lost, if care be not taken to confine the mixture immediately in those vessels by means of which it is to be distilled.

The volatile salt obtained by this operation is white, pure, and very active; having been freed from the greatest part of its superfluous fat matter, both by the union it had contracted with the marine acid, and by the fixed alkali employed to separate it therefrom. This salt is so quick and volatile, that if, on taking it out of the receiver, it be left a little too long exposed to the air, before it be put into the bottle in which it is to be kept, a great deal of it will exhale and be lost. For the same reason care should be taken, while the vessels are unluting, that the vapour of this salt do not strike the organ of smelling, or be drawn into the lungs in respiration; for it affects those organs so powerfully, and makes such a quick impression on them, that the operator

operator would be in danger of suffocation. Yet it is of great service when cautiously smelled to, for exciting the vibrations of the *genus Nervosum*, in apoplexies, fainting fits, and hysterical disorders. But it must always be administered with great caution: for it hath a corrosive quality, and is no less caustic than a fixed alkali. This is proved by applying it to the bare skin, and keeping it on by means of a pitch plaister, so that it cannot fly off in vapours: for as soon as it begins to grow warm, it produces on the skin a smarting sensation, like that of burning, attended with much pain, and in a very short time makes an eschar like a caustic.

The volatile spirit, obtained in the decomposition of sal ammoniac by a fixed alkali, derives its origin from the phlegm contained in the saline matters that are mixed together on that occasion. The moister those matters are, the more spirit there will be. This also is very active and penetrating. But as it owes those qualities wholly to the volatile salt dissolved in it, the more this spirit comes off, the less salt will there be.

If you desire to have much volatile spirit, a quantity of water proportioned to the quantity of spirit you want, must be mixed with the salts. In this case the distillation begins with a humid vapour, which coagulates on the sides of the receiver into a concrete salt, almost as soon as it comes over. There rises afterwards an aqueous vapour, not so saline and volatile as the former. This liquor dissolves the salt that was coagulated before; and, if the water added was in sufficient quantity, it will dissolve the salt entirely; otherwise it will dissolve but a part thereof, and then it is certain that the liquor is a volatile spirit as strongly impregnated with salt as it can be. The reason why the liquor that rises first contains a great deal more volatile salt than the other, in so much that it coagulates and

and becomes solid, is because the volatile salt rises in distillation much more easily than water.

In whatever manner the volatile spirit or salt be distilled from sal ammoniac, by means of a fixed alkali, we always find at the bottom of the retort, or cucurbite, when the operation is finished, a new neutral salt compounded of the acid of the sal ammoniac, and of the alkali used in the distillation. If the salt of tartar be used, this new natural salt will be perfectly like that produced by combining this alkali with the acid of sea-salt, to the point of saturation. The figure of the crystals of this salt, though much like that of the crystals of sea-salt, is nevertheless a little different. However, this salt possesses the chief properties of sea-salt. It bears the name of *sal Febrifugum Sylvii*, because that physician attributed to it the virtue of curing intermitting fevers. But its title to this virtue is very doubtful, at least in this country.

If the salt of soda be used, instead of salt of tartar, to decompound sal ammoniac, a volatile spirit and salt will in like manner be obtained; and the neutral salt left in the retort, after distillation, will be a true regenerated sea-salt, perfectly like native sea-salt; because, as we have said before, the salt of soda is of the same kind with the natural basis of sea-salt; and the inconsiderable differences observable between the *sal febrifugum* and sea-salt, can be attributed only to such as may be found between the alkaline bases of those two salts.

PROCESS V.

Sal Ammoniac decompounded by Absorbent Earths and Lime. The Volatile Spirit of Sal Ammoniac. Fixed Sal Ammoniac. Oil of Lime.

LET one part of sal ammoniac, and three parts of lime, slaked in the air, be pulverized separately,

rately, and expeditiously mixed together. Put this mixture immediately into a glass retort, so large that half of it may remain empty. Apply thereto a capacious receiver, with a small hole in it to give vent to the vapours, if needful. Let your retort stand in the furnace about a quarter of an hour, without any fire under it. While it stands thus, a great quantity of invisible vapours will rise, condense into drops, and form a liquor in the receiver. Then put two or three live coals in your furnace, and gradually increase the fire till no more liquor will rise. Now unlute your vessels, taking all possible care to avoid the vapours, and quickly pour the liquor out of the receiver into a bottle, which you must stop with a crystal stopple rubbed with emery. There will remain, at the bottom of the retort, a white mass, consisting of the lime employed in the distillation, together with the acid of the sal ammoniac: this is called *fixed sal ammoniac*.

OBSERVATIONS.

In our Elements of the Theory, we explained how we imagine that lime and other substances, which, according to the table, have less affinity than volatile alkalis with acids, are nevertheless capable of decomposing sal ammoniac, by uniting with its acid, after expelling it from its basis, which is a volatile alkali. To recapitulate our opinion in two words: we conceive this to depend on the fixedness of these earthy and metallic additaments, which enables them to resist the force of fire, and on the volatility of the basis of sal ammoniac, which proves a great disadvantage to it when it comes to struggle, as it were, with those fixed additaments, aided by a considerable degree of heat. We shall only observe, that we are not singular in this opinion, nor indeed did we deliver it as a new one; that

that several modern chymists concur with us therein, and particularly Mr. Baron, whom we have already mentioned more than once on the subject of Borax; and who, we think, was the first that ever took particular notice of it in print, viz. in his memoirs on Borax, communicated to the academy before the publication of our elements. For the explanation of this phenomenon, therefore, we refer to those memoirs, which are actually published, and to what we have already said on the subject in our treatise above mentioned.

Another phenomenon, which is equally singular and curious, furnishes us with matter for several reflections, and gives us occasion to relate, in few words, the result of Mr. Duhamel's most sagacious experiments and speculations tending to discover the cause thereof. The point under consideration is the different forms and properties which the volatile alkali assumes, when separated from sal ammoniac by the means of a fixed alkali, and by the means of lime. We know that the former is always in a concrete form, unless the mixture, from which it is distilled, be absolutely drenched with water; and that the latter, on the contrary, is always in a fluid form, and constantly liquid, whatever method be taken to distill it.

Some chymists imagine that the volatile salt of sal ammoniac appears in a concrete form, only because it still contains some acid; whence they conclude, that the reason why no concrete volatile salt can be obtained by the means of lime is, because it absorbs all the acid of the sal ammoniac; which is not the case, they say, with fixed alkalis. Others impute the constant fluidity of the volatile spirit of sal ammoniac, obtained with lime, to the particles of fire which they suppose communicated thereto by that substance. Mr Duhamel equally refutes both these opinions, by proving from experiments that fixed alkalis are capable of absorbing as much

acid as lime can, and even more; and that having been calcined as long, and with as violent a fire, as lime, they must maintain and communicate as many particles of fire; if indeed it be possible that the particles of fire should actually be lodged, and continue imprisoned, in calcined substances, as these gentlemen suppose. Yet this is contrary to experience; seeing the volatile salt distilled by the means of a fixed alkali, though ever so long and ever so violently calcined, is always in a concrete form, and doth not resemble the volatile spirit of sal ammoniac prepared with lime.

In order to throw the necessary lights on this point, Mr. Duhamel had recourse to the only method that can be depended on in natural philosophy; namely, experiments. He accordingly made several, of which these are the chief.

First, he distilled a volatile salt, by the means of well desiccated salt of tartar, and salt of soda; and, urging the fire with great violence towards the end of the operation, he thus obtained a quantity of volatile salt equal to, or even exceeding, that of the sal ammoniac he used: whence he justly concluded, that, on this occasion, the volatile salt carried up and volatilized some of the fixed salt.

Secondly, he found upon trial, that the volatile spirit obtained from sal ammoniac, by the means of lime, appears in the form of a liquor, only because it is mixed with some water which was contained in the lime. Of this truth he had the following decisive proof: having attempted to prepare a volatile spirit of sal ammoniac with lime, which had not been flaked, either in the air or by water, he could not obtain any volatile spirit; or, at least, the quantity was so small that it might be reckoned as nothing; and even that was wholly due to the moisture which sal ammoniac necessarily contains, together with that which lime imbibes from the air, if ever so little exposed thereto.

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From these two experiments Mr. Duhamel draws the following consequences: viz. that the volatile salt cannot be separated from the sal ammoniac and sublimed, without carrying along with it some of the additament which serves to extricate it; or, instead thereof, some other body with which it is capable of uniting; that fixed alkalis have the property of being thus carried up by the volatile alkali, and subliming with it: that the case is not the same with lime, which therefore cannot, when alone, separate and sublime the volatile alkali of the sal ammoniac; but becomes capable thereof when it hath imbibed any moisture, which joins with the volatile salt, and rises therewith in distillation. And hence it must be concluded, that, seeing the volatile salt carries up with it some of the fixed alkali, by the means of which it is separated, it will be in a concrete form; what it carries up along with it being dry and solid: whereas, when it is distilled with lime, it cannot but be liquid; seeing it must needs be dissolved by the moisture it gets from the lime, without which it would not rise.

But to what must we attribute these effects produced by lime, so different from those produced by fixed alkalis. Are they owing to its quality of lime? or would it produce the same, if it were only a mere absorbent earth? Mr. Duhamel hath answered this question by a third sort of experiment. He tried to decompose sal ammoniac, and to separate its volatile alkali, by a pure absorbent earth, without mixing any water with it, or calcining it.

For this purpose he made use of chalk; and his experiment succeeded. By means of this additament he decomposed sal ammoniac, and by the experiment obtained the lights he wanted. The volatile alkali, being extricated by the dry but uncalcined chalk, rose in a concrete form, as with fixed alkalis; and in like manner carried up with it

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some of the earthly additament. The same chalk when calcined, and converted into lime, produced the very effect of lime on sal ammoniac. It is therefore from calcination alone that absorbent earths derive the property of retaining obstinately the volatile alkali, and preventing its sublimation by refusing to rise with it as fixed alkalis do.

Though these ingenious experiments evidently furnish us with great lights, for discovering the cause of the solidity or fluidity of the volatile alkali, when separated from sal ammoniac by different additaments, as they fully determine several preliminary questions immediately relating thereto; yet they still leave us, in some measure, at a loss with regard to the chief point. For we do not yet know why fixed Alkalis and absorbent earths, which, in all chymical trials, shew that they have certainly as much fixity as lime, are carried up by the volatile alkali, while lime resists, instead of rising with it as those other substances do, obstinately retains it, and even fixes it in some measure, so that it is impossible for it to sublime. This question, in my opinion, depends on the theory of lime; nor can we hope to resolve it, in its full extent, till we get a further insight into the nature of that singular substance than we have at present.

On this subject, however, Mr. Duhamel hath offered some conjectures founded on the known properties of lime, and supported by experiments.

“ Lime, says he, is an earth freed by calcination,
 “ from almost all its humidity, almost all its acid,
 “ and all the fat it contained; whether that fat
 “ came from some animal parts, as is the case of
 “ those stones which consist of shells; or whether
 “ it were a bituminous fat, as may happen to be
 “ the case with some others: this substance is
 “ withal acrid and fiery; it is very greedy of moi-
 “ sture, and imbibes it when exposed thereto. It
 “ absorbs acids, and retains them strongly; and
 “ lastly

“lastly, it unites with fat matters, and therewith
“makes a kind of soap.”

All these properties are verified by experiments ; and therefore Mr. Duhamel thinks he hath a right to say, that lime acts not only on the acid of sal ammoniac, but also on the fatty matter which always accompanies volatile alkalis, and is essential to their nature, and therefore it decomposes them. Of this Mr. Duhamel gives the following convincing proof, founded on experiment. He took some volatile spirit distilled with lime, and abstracted it several times from a fresh parcel of quick lime. The quantity of the spirit diminished sensibly every time ; and the lime was at last so replete with fat, that the vitriolic acid, when poured thereon, became very sulphureous ; and moreover, when calcined in a crucible, it emitted a very perceptible smell of burnt grease.

Indeed fixed alkalis are also capable of absorbing and retaining fat matters ; but not near so strongly as lime : because these salts are never entirely freed from that which they contain originally ; whereas lime seems much poorer, and absolutely void of any oily matter.

On these principles Mr. Duhamel resolved to try if he could not obtain a volatile alkali in a concrete form, by distilling the volatile spirit from lime, brought nearly to the condition of a fixed alkali, by imbibing a portion of fat matter. With this view he distilled a great quantity of volatile spirit from a little lime, and actually obtained a small portion of volatile salt ; because the great quantity of volatile spirit had, in some measure, saturated the lime with fat matter.

Mr. Duhamel tried also to bring lime back to the condition of a pure absorbent earth, to *decalcine* it, if I may use the term, in order to try whether he could not by this means make it produce the same effect as chalk. For this purpose he lixiviated some

lime four months successively, pouring every day fresh water on it, and removing that of the preceding day, together with the crystalline crust which always formed on it; and, after leaving this lime two years in the shade, he applied it to sal ammoniac. It produced a moderate quantity of volatile salt, which was very transparent, and seemed to be crystallized in cubes. Thus we see lime rendered very like chalk. Yet it was pretty acrid on the tongue, and the volatile salt, obtained by its means, was more disposed to run into a liquid than that separated by chalk: which shews, that this lime still retained some part of its former character, and that its transformation was not complete.

To conclude what relates to the volatile alkali of sal ammoniac, it only remains that we say a word or two of that portion of the earthy or saline additament, which, though fixed in its nature, sublimes nevertheless with the volatile alkali, and gives it a concrete form.

Mr. Duhamel, who, in every subject that he handles, omits nothing worthy of attention, made several other experiments, with a view to discover whether or no the salt of tartar, and the chalk, carried up by the volatile alkali, be truly volatilized; and whether or no there be such a strict union contracted, between the urinous salt, and these fixed substances, that the whole results in what is called a *concrete volatile salt*; or if those fixed substances be united but superficially with the urinous salt, which only carries them up along with itself in sublimation, as sal ammoniac carries up several very fixed metallic matters.

The result of the experiments made by Mr. Duhamel for this purpose is, that the fixed substances carried up by the volatile alkali of the sal ammoniac are actually volatilized; that they make, as it were, one whole with it; and are so closely combined therewith, that almost all the most efficacious means

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of separating fixed from volatile matters are unsuccessful with regard thereto. Nothing, for instance, is fitter to separate a volatile substance from a fixed one, than to mix the compound with a great quantity of water, and to distill the whole, with such a degree of heat as shall be exactly sufficient to elevate the volatile part. In this manner Mr. Duhamel treated volatile alkalis replete with fixed salt, and with chalk: but though he applied no more than the gentlest degree of heat; nay, exposed his mixture to the air only, fearing lest he should make the heat too strong if he used fire; yet the fixed part, which the volatile salt had carried up with it, continued still united therewith; so that the whole passed over in distillation, or was dissipated by evaporation, without leaving any thing fixed at the bottom of the vessel.

He also justly looked on acids as an effectual means of procuring the separation, or decomposition, he was in quest of. We know that, with the volatile alkali, they form ammoniacal salts, which, though they are not so light as the volatile alkali, sublime nevertheless with a moderate heat; and that, on the contrary, the same acids, with fixed alkalis, or absorbent earths, form neutral salts, which resist the violence of fire. On this principle Mr. Duhamel poured acids, to the point of saturation, upon volatile alkalis containing much fixed alkali, or chalk. But this experiment succeeded no better than the foregoing; for the mixture, being put to distill, sublimed wholly in sal ammoniac. Indeed a little fixed matter was left at the bottom of the retort; but the quantity thereof was too small to merit notice.

At last, the only way Mr. Duhamel could think of, for separating, from a concrete volatile alkali, the fixed parts which that salt had rendered volatile, was to expose it to the air, covered with a piece of gauze only; but in its dry state, without dissolving it

it in water. The volatile urinous salt was by this means dissipated; having deserted the fixed part, which remained at the bottom of the basin, and, being exposed to the fire, retained its fixed nature. But it took more than a year to effect this separation; nor are we sure that it was complete; for it is not certain that all the fixed part was left behind, and that some of it was not dissipated with the volatile urinous salt.

This volatilization, this kind of metamorphosis of a fixed alkali and an absorbent earth into a volatile alkali, is a very curious phenomenon, and deserves to be considered by the best chymists.

We shall finish our observations on the decomposition of sal ammoniac by lime, with some reflections on the nature of the *caput mortuum* that remains after this distillation.

This residuum is only lime impregnated, but not saturated, with the acid of sea salt. If the distillation be urged at last with a violent fire, the *caput mortuum* will be found formed into a mass, seeming to have been half-melted. This matter is a kind of phosphorus, and emits light in the dark, when struck with any hard body. Mr. Homberg was the first who discovered it to have this property. Having calcined, and melted together in a crucible, one part of sal ammoniac and two parts of lime, with a design to fix that salt, he observed the mass remaining after the fusion to have the property just mentioned.

Lime, thus impregnated with the acid of sal ammoniac, is very improperly called by the name of *fixed sal ammoniac*. This compound attracts the moisture of the air, and even runs wholly into a liquid, if it be impregnated with much acid. It hath almost all the properties of fixed alkalis. This liquid is called *oil of lime*, for the same reason that deliquated salt of tartar is called *oil of tartar*.

PROCESS VI.

Volatile Alkalis combined with Oily matters. A volatile Oily Aromatic Salt.

PULVERIZE and mix together equal parts of sal ammoniac and salt of tartar: put the mixture into a glass or stone cucurbit: pour on it good spirit of wine, till it rise half an inch above the matter. Mix the whole with a wooden spatula; apply a head and a receiver, and distill in a sand-bath, gently heated, for two or three hours. A volatile salt will rise into the head; and then the spirit of wine will distill into the receiver, carrying with it a portion of the volatile salt.

When nothing more will come over, let your vessels cool; then unlute them, separate the volatile salt, and weigh it directly. Return it into a glass cucurbit, and for every ounce thereof add a dram and a half of essential oil, drawn from one or more sorts of aromatic plants. Stir the whole with a wooden spatula, that the essence may incorporate thoroughly with the volatile salt. Cover the cucurbit with a head, fit on a receiver, and, having luted it exactly, distill in a sand-bath, as before, with a very gentle heat. All the volatile salt will rise, and stick to the head. Let the fire go out, and, when the vessels are cooled, take your salt out of the head. It will have an odour compounded of its own proper smell, and the smell of the essence with which it is combined. This is an *aromatic oily salt*. Put it into a bottle stopped close with a crystal stopple.

OBSER-

OBSERVATIONS.

The design of this operation is to incorporate and unite an oil with a volatile alkali. Spirit of wine is added in the distillation of the volatile salt, intended for this purpose, in order to prepare it for receiving the oil, and combining more easily therewith. This salt hath the property, as was shewn in the preceding operation, to carry up with it part of the substances with which it is distilled. On this occasion therefore, it is impregnated with a little of the spirit of wine; and this spirit, which contains in itself an oily matter, and is the solvent of oils, cannot fail to facilitate the union of the oil with the volatile salt, as it serves for a medium between them. Yet it must not be considered as a necessary one. A volatile salt, sublimed with salt of tartar alone, would also very readily take up any oil with which it should be distilled. We have seen, that volatile alkalis are originally impregnated with much oil, which is radically dissolved in them; and consequently they have a great affinity with that substance. So that if we distill them with spirit of wine, at the beginning of this operation, we do it not out of any necessity, but only with a view to accelerate or facilitate the intended union.

In this distillation the volatile alkali always rises first, and before the spirit of wine; which proves that it is much more volatile, though it be more ponderous than the spirit.

If the spirit of wine used in this distillation be very aqueous, it will dissolve the salt as it comes over, and will reduce it into a spirit: but if, on the contrary, it be well dephlegmated, the volatile alkali will remain in a concrete form, and will not be dissolved in this first distillation.

If you desire to have the volatile salt entirely dissolved in the spirit of wine, though highly dephlegmated,

phlegmated, it must be repeatedly distilled a great number of times with the same spirit of wine: for, though the small quantity of spirit of wine, with which it unites in the first distillation, be not capable of reducing it into a liquid, yet, as it takes up more and more every time it is distilled, it dissolves at last, and then with the spirit of wine forms a fluid that appears perfectly homogeneous. The volatile alkali is now rendered considerably milder by the union thus contracted, and is accordingly called the *dulcified volatile spirit of sal ammoniac*.

When well dephlegmated spirit of wine is mixed with a volatile spirit of sal ammoniac, perfectly saturated with volatile salt, these two liquors together immediately form a white opaque *coagulum*. But for this purpose you must not use a volatile spirit distilled with lime; for then the experiment will not succeed.

This *coagulum* does not seem to be the effect of an intimate union between the two substances mixed together, like that which results from the union of a fixed alkali with an oil. It hath just now been shewn, that spirit of wine and a volatile alkali do not readily unite together. I believe the effect rather depends on this, that spirit of wine hath a greater affinity than the volatile salt with water; and therefore the spirit, which ought to be perfectly dephlegmated, attracts the water wherein the volatile salt was dissolved, which thereupon recovers its concrete form; and being at that time mixed with the spirit of wine, it keeps that spirit locked up among its parts, and hinders it from appearing with its natural fluidity.

What confirms this notion is, that the *coagulum*, which at first seems to make but one whole, soon separates into two parts, whereof one, which is solid, and nothing but the volatile salt concreted, lies at the bottom of the vessel; and the other, which is fluid, cannot be mistaken for any thing but the spirit

spirit of wine, which, being disengaged from the particles of salt, recovers the form of a liquid, and, being the lightest, floats over the salt. Yet these two substances, though now very distinct from each other, are not so pure as before they were mixed together. The spirit of wine hath dissolved a little of the volatile salt; and, on the other hand, the volatile salt retains a little of the spirit of wine. They may indeed be perfectly united and blended with each other, by the method above delivered; that is, by being frequently distilled and cohobated together, till they form one mixt; but then that mixt will be in a liquid form.

The first time this mixture is distilled, a great deal of volatile salt rises first, which is very fit to unite with an essential oil, and so to become a volatile oily aromatic salt.



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